North East Linguistics Society

Volume 26 *Proceedings of the North East Linguistic Society 26*

Article 9

1996

Conjunctive Constraints and Templates in Optimality Theory

Mark S. Hewitt
Brandeis

Megan J. Crowhurst
UNC-CH

Conjunctive Constraints and Templates in Optimality Theory*

Mark S. Hewitt and Megan J. Crowhurst

Brandeis and UNC-CH

In this paper we argue that Optimality Theory must allow constraints to form dependency relationships in the form of conjunctions using the logical operator ∧ ('and'). In our view, a set of conjoined constraints is violated as a whole if (and only if) at least one of the constraints in the set is violated. We also argue that conjunction is limited to cases where the conjoined constraints share an argument, or *fulcrum*; which delimits the evaluation domain for the conjunction. Our formal system captures both fully non-gradient as well as partially gradient evaluation among constraints. Evidence for conjunction is drawn from cases in which the criterion of minimal violation fails to predict attested surface representations when constraints are evaluated independently. We examine two such patterns; the assignment of stress in Dongolese Nubian and in Diyari; and show that an analysis which recognizes conjunction predicts attested outputs under otherwise standard assumptions concerning the evaluation of interacting constraints in OT.

The Optimality Theoretic (OT) framework, as proposed by Prince & Smolensky (1991, 1993 [= P&S]) and developed in McCarthy & Prince [= M&P] (1993a,b; 1994) and numerous other works, relies on the dominance ranking of output constraints through which a set of candidate representations is filtered to determine the optimal output representation for a given input. The optimal candidate is chosen by the criterion of *minimal violation:* the best candidates violate top-ranking constraints the least. In OT to date, output constraints (defined by UG and present in all phonological grammars) have been assumed to participate in only two relationships: (i) pairs of constraints may be stratified, or *ranked*, in hierarchical interactions in which a constraint A crucially dominates a constraint B, in which case we write *A » B*; or (ii) they may be *unranked*, signifying that the interaction of A and B is not crucial for optimization. In any constraint configuration, the evaluation function (H-Eval) will choose the candidate which violates the constraints the least under the criterion of minimal violation as shown in (1), where A » B » C.

(1)

	A	B	C
Cand1	*	* *	* * *
Cand2	*	* * *!	* *

* We acknowledge with appreciation the remarks of NELS participants, and especially the insightful comments of our colleague Scott Myers.

Below, we present two cases where the evaluation criterion of minimal violation leads to the wrong predictions. These cases involve a loss of gradience in the evaluation of certain constraints; that is, cases where multiple violations are *no worse* than one violation, so that the difference in the number of violations for constraint B in Cand1 and Cand2 of (1), for example, does not determine the optimal output.

A related issue addressed in this paper is dependency. The null assumption is that there are few (if any) dependencies among the constraints and that they are independently rankable. If this is correct then any logical possible ranking of the individual constraints should result in a natural grammar. However, there are reasons to doubt that all logically possible rankings of constraints are actually attested. As an example, the *Faithfulness* constraints (the *Parse* and *Fill* families) have been highly ranked in fragments of OT grammars proposed to date. Suppressing the *Faithfulness* constraints, while certainly possible, would lead to grammars permitting virtually indiscernible relationships between inputs and outputs through freely underparsing or epenthesizing to satisfy other constraints. Another reason to suspect that rankings are not entirely free is that OT assumes a notion of markedness under which certain configurations are more common than others. Random generation of rankings across languages should banish to statistical oblivion the clusterings associated with well-known markedness relations. (Note, however, that markedness can be captured by tailoring the definitions of constraints as well as through their rankings. P&S elegantly represent the markedness relation between CV and CVC syllables by dovetailing the definitions of the *Onset* and *NoCoda* constraints.)

In this paper we argue that the considerations discussed above force OT to admit a third type of relationship between constraints, one which takes the form of a conjunctive dependency. In a conjunctive dependency, a set of conjoined constraints is violated whenever at least one of the constraints in the set is violated; conversely, a conjunction is *un*violated only when none of its conjuncts is. In other words, a constraint violation in our system is equivalent to *False* in the truth table for conjunction as standardly defined by logicians, such that a logical conjunction is truth-conditionally false whenever one of its conjuncts is false.[1] We illustrate this parallel between the truth table for a logical conjunction and the violation chart for the constraint conjunction in (2). (The status of the conjunction as a whole is shown in the columns headed by the logical operator $\wedge$.)

(2) (a) Logical conjunction

Assertion A	$\wedge$	Assertion B	
T	**T**	T	✓
T	**F**	F	
F	**F**	T	
F	**F**	F	

(b) Constraint conjunction

	Constraint A	$\wedge$	Constraint B
✓			
		*	*
	*	*	
	*	*	*

As the chart in (2b) makes clear, the evaluation of conjoined constraints differs from evaluation in the standard, unconjoined relation in that conjunction results in a type of non-gradience previously unexpressed in OT, which departs from the strictest interpretation of minimal violation: the conjunction in (2b) receives a single '*' when *either* or *both* of its conjuncts is (are) violated, as opposed to the maximum double violation possible if the two constraints were simply unranked. In other words, the violation of all constraints in a conjunction is no worse than the violation of any subset of the participating constraints.

[1] A different view of constraint conjunction has been proposed by Paul Smolensky (1993), in which a constraint violation is equivalent to *True* in the logical truth table. The evidence cited by these authors and in our own work clearly indicates that both relations are necessary. The issue of whether the two approaches to conjunctions can be unified is pursued in Hewitt & Crowhurst (in preparation).

In the remainder of this paper, we show that the conjunctive relation introduced here is crucial for capturing two distinct types of linguistic patterns which surface in a number of languages. The two patterns we examine are the familiar metrical edge-to-opposite-edge-default pattern found in so-called edge/-edge languages such as Dongolese Nubian, and the morphology-dependent metrical system of Diyari. Though the similarities among these languages are by no means immediately evident, the adequate characterization of each requires the formal device of constraint conjunction. We also argue that constraint conjunction is limited to cases where the conjuncts share an argument, the *fulcrum*, which defines the evaluation domain for the conjunction.

1. Default to the Opposite Edge

The need for constraint conjunction and the details of our approach can be simply illustrated through reference to phonological phenomena whose descriptions standardly take the form "If *X* Then *Y*, Otherwise *Z*". We show that the constraints comprising the "If...Then..." portions cannot be independent, and must be conjoined. An example of the type of dependency we are discussing is found in the familiar edge/-edge stress pattern of Dongolese Nubian, described by Armbruster (1960, 1965). The generalization for Dongolese stress is stated in (3); representative examples appear in (4) (page numbers following cited forms refer to Armbruster 1960).[2]

(3) Dongolese stress:
(i) If a form contains one or more heavy syllables, stress the rightmost heavy;
(ii) otherwise, stress the initial syllable.

(4)a.	bɛ́ɛkatʊ	'to be killed' xiii	b.	búrun	'it is a girl' xiii
	dogóogɪr	'raise it' xiii		tʃáraga	'page, leaf' 193
	tɛlɛgráaʃkɪ	'a telegram' 90		múgosan	'tell to leave' 145
	tʊntʊnɛ́ɛŋkɛgɪd	'their maternal aunt' 199		ǧɪ́ñʊran	'tell him (her) to go and wait' xiii
	maasúura	'tube, pipe' 139			
	maalɛ́ɛʃ	'it doesn't matter' 136			
	sɛrɛɛgɪrʃuglɛɛrɛdáag	'be in the situation of having worked well' 175			

The constraints needed to account for this pattern are *HeavyHead* (accounting for Dongolese's sensitivity to prominence), *RightmostHead* and *LeftmostHead*, given in (5).

(5)	a.	HeavyHead:	The head σ of a Foot is bimoraic, μμ.[3]
	b.	RightmostHead:	Align (Head(F), R, PrWd, R).
	c.	LeftmostHead:	Align (Head(F), L, PrWd, L).

HeavyHead requires stressed syllables to be heavy, and returns a violation for any stress-bearing light syllable. RightmostHead and LeftmostHead require that the stress-head be right- and left-aligned within its domain. Violations are evaluated gradiently, so that a mark * is returned for every syllable separating the stress-head from the relevant edge.

---

[2] The pattern described here is reported by Hayes (1980/5). A survey of Armbruster (1965) seems to confirm (3) 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.

[3] This constraint reflects the proposals of Crowhurst (1991) for placing minimality conditions on heads.

To capture the basic descriptive generalization for Dongolese that stress falls on a heavy syllable if one is available, it is necessary for HeavyHead to be highly ranked in any account. A classical non-conjunctive treatment is unsuccessful in determining the ranking order of RightmostHead and LeftmostHead: RightmostHead must dominate LeftmostHead in forms containing heavy syllables, otherwise Dongolese would stress the leftmost and not the rightmost heavy syllable (predicting *máa.suu.ra); but the opposite ranking LeftmostHead » RightmostHead is needed to account for initial stress in forms with no heavy syllables (e.g. mú.go.san). The tableau in (6) shows that in a non-conjunctive analysis which adopts the usual evaluation criterion of minimal violation, the ranking RightmostHead » LeftmostHead predicts the correct output for forms containing heavy syllables, but not for forms with only light syllables. (We assume bimoraic foot structure.)

(6)

Cands.	HeavyHead	R-most Head	L-most Head
a. maa (súu) ra ✓		*	*
b. (máa) suu.ra		* *!	
c. maa.suu (rá)	*!		* *
a. (mú.go) san	*	*! *	
b. mu (gó.san)	*	*!	*
c. mu.go (sán) ✘	*		* *

Tableau (7) demonstrates that the opposite pattern is predicted under the alternative ranking LeftmostHead » RightmostHead.[4]

(7)

Cands.	HeavyHead	L-most Head	R-most Head
a. maa (súu) ra		*!	*
b. (máa) suu.ra ✓			* *
c. maa.suu (rá)	*!	* *	
d. (mú.go) san ✘	*		* *
e. mu (gó.san)	*	*	*
f. mu.go (sán)	*	* *!	

Non-conjunctive ranking, then, leads to an ordering paradox in an OT analysis of Dongolese stress.

Intuitively, it is clear that RightmostHead and HeavyHead must both be highly ranked, as in (6), since they prevail when the relevant quantitative condition is met. What is lacking in the non-conjunctive account is a means of expressing the dependency between syllable weight and rightmost stress; when no heavy syllables are present, RightmostHead as well as HeavyHead is not enforced. By treating HeavyHead and RightmostHead as conjoined we achieve exactly this result, and predict the attested forms in all cases. LeftmostHead, the constraint which decides between candidates in the default case where a form contains no heavy syllables, is ranked below the conjunction. We therefore propose the ranking in (8).

(8) HeavyHead ∧ RightmostHead » LeftmostHead

[4] Unattested forms incorrectly predicted to be optimal are marked in tableaux with '✘ '. A dotted line between columns in tableaus indicates that the constraints on either side are unranked; a solid line signifies a crucial ranking relationship where the constraint to the left dominates the one on the right; '!' after '*' signals the fatal violation for that candidate, and the following cells for that candidate are shaded.

Recall that in a conjunction, as defined in our system, each condition must be met for the conjunction to be satisfied. In other words, the conjunction is violated if either or both of the conjuncts is (are) violated. Furthermore, as we noted earlier, there is a sense in which a conjunction of constraints can lead to a completely non-gradient evaluation of those constraints, collapsing multiple violations on the individual conjuncts into a single violation of the conjunction as a whole. We set out our reasoning below.

Each of the constraints HeavyHead and RightmostHead imposes a condition of maximum harmony on a specific individual--the head of the stress foot. We refer to this argument, shared by the conjoined constraints, as the *fulcrum* of the conjunction. We propose that the evaluation of every conjunction is relativized to the fulcrum, so that the very relation of conjunction is restricted to sets of constraints for which a fulcrum can be defined--that is, to sets of constraints sharing an argument. Why must this be the case? Consider that every constraint has a focus, or an argument on which a condition is predicated. The focus of the constraints Onset and NoCoda (P&S), for example, is the syllable; the focus of an Alignment constraint (M&P 1993b) is the universally quantified argument. If a conjunction is to be evaluated as a single entity, then it too must have a focus, just as unconjoined constraints do. We propose that this focus is defined by the fulcrum. In what follows we represent the fulcrum in raised script to the right of the logical operator, so that (8) is more explicitly stated as *HeavyHead* $\wedge^{Head(F)}$ *RightmostHead*.

How is the evaluation of a conjunction relativized to its fulcrum? In two ways. The first is related to the fulcrum's role in delimiting the domain within which violations of the conjunction are assessed. Our basic intuition is that the evaluation domain encompasses only the set of elements eligible to be the fulcrum targeted by the conjoined constraints--the "microcandidates" for fulcrum status. The criterion for eligibility here is quantity, imposed by HeavyHead. As we will show, rightmost-ness matters for evaluating the conjunction as a whole, but plays no role in restricting the evaluation domain, at least in forms with heavy syllables. This indicates that even within a conjunction such as our HeavyHead $\wedge^{Head(F)}$ RightmostHead, constraints may be ranked. In our example, HeavyHead outranks RightmostHead.[5] Consider our tableau for the form *maasúura* in (9). (Violations of constraints within a conjunction that are not passed up directly are enclosed in parentheses.)

(9)

Cands.	HeavyHead	$\wedge^{Head(F)}$	R-mostHead	L-mostHead
a. maa (súu) ra ✓				*
b. (máa)suu.ra		*!	(*)	
c. (màa)(súu)ra		*!	(*)	*
d. maa.suu (rá)	(*)	*!		* *

The attested form in (9a) is correctly selected as optimal because no violation is assessed against the conjunction, even though the form ends in a light syllable. It must therefore be the case that no violations are returned for light syllables separating heavy syllables from the right edge of the prosodic word.[6] In other words, in forms containing both light and heavy syllables, only the heavy syllables are relevant in assessing right-alignment in the conjunction HeavyHead $\wedge^{Head(F)}$ RightmostHead.

---

[5] If RightmostHead were the more highly ranked constraint, then the domain of evaluation should be restricted to rightmost syllables. In an edge/-edge metrical system, the expected surface reflex of this ranking should be "If the rightmost syllable is heavy, stress it; otherwise, stress the initial syllable."

[6] This interpretation is reminiscent of the standard interpretation of how tone and feature spreading behave in systems where non-bearing segments are transparent; only *potential* bearers for a feature matter.

How does this result follow from conjunction-internal ranking? As top-ranked conjunct, HeavyHead functions as a filter in restricting the evaluation set for the conjunction to just the set of elements eligible to be fulcrums under HeavyHead's quantitative requirement (i.e. the set of heavy syllables). Candidates with heavy syllables will satisfy HeavyHead; these are passed to RightmostHead, with the evaluation domain still restricted so that only members of the evaluation set (heavy syllables) are interpreted as possible violators of RightmostHead. In candidates containing only light syllables, however, the evaluation domain defined by HeavyHead is null. All such candidates violate HeavyHead, and the deciding role falls to Rightmost-Head, which also inherits the task of establishing a domain of evaluation under its own requirements. Since RightmostHead imposes no quantitative restriction, any syllable is a possible Head(F), and so any syllable intervening between the stress-head and the right edge of the word is a violator of RightmostHead, regardless of quantity. This means that the evaluation domain may be differently restricted in different candidate forms, depending on the harmonic properties of "microcandidates" available for fulcrum status, as illustrated in (10).

(10)	{σ: σ: σ:}	{σ: σ:}	
	σ σ: σ σ σ: σ σ:	σ: σ: σ	{σ σ σ}
	sɛ rɛɛ gɪr ʃug lɛɛ rɛ dáag	maa súu ra	mú go san

The tableau for *múgosan* which contains only light syllables is shown in (11)

(11)

Cands.	HeavyHead $\wedge$Head(F) R-mostHead			L-mostHead
a. (mú.go)san ✓	(*)	*	(* *)	
b. mu (gó.san)	(*)	*	(*)	*!
c. mu.go (sán)	(*)	*		*! *

Candidate (11a) is correctly selected as optimal in the tableau above since all candidates violate the conjunction, and so LeftmostHead determines the outcome.[7]

The second way in which the evaluation of a conjunction is relativized to its fulcrum is connected to the fulcrum's role in limiting violations against the conjunction, resulting in a narrower type of gradience than holds between constraints in the *ranked* and *unranked* relations. We showed above that an analysis of Dongolese stress which does not conjoin the constraints HeavyHead and RightmostHead is unsuccessful because there is no way to select the attested form (11a) (= (7d)) as opposed to (11c) (= (7f)), which should be expected under the criterion of minimal violation. Constraints in a conjunctive relationship do not exhibit the expected gradient interpretation of violations; rather, they show either a narrower form of gradience or complete non-gradience in evaluation. In other words, the conjunctive account succeeds because it compresses all violations on the individual conjuncts into a single violation on the conjunction as a whole. Under this interpretation, candidate (11a), with three violations against HeavyHead and RightmostHead is no worse than (11c), with only one violation against HeavyHead.

Finally, we draw attention to the fact that Dongolese permits only one stressed syllable per word; secondary stress is absent. This, too, is an effect of the conjunction

[7] We assume that constraint conjunction is a marked relation. Thus, our account predicts that edge/-edge systems, exemplified here by Dongolese, are more marked than edge/edge systems in which stress defaults to the same edge when other preferred conditions are not met (e.g. prominence), as in Khalkha Mongolian (Poppe 1951, Street 1963). The Khalkha system ("stress the leftmost heavy syllable if there is one; otherwise, stress the initial syllable"), is produced under the nonconjunctive ranking HeavyHead » LeftmostHead.

used in our analysis. The constraint RightmostHead requires that the heads of feet be right-aligned within the appropriate domain. Given this requirement, the candidate *(màa)(súu)ra in tableau (9) fails because the first stress-head violates the conjunction, while the optimal candidate maa(súu)ra does not. Thus, our analysis requires no additional machinery to account for the conflating properties of Dongolese stress.[8,9]

To summarize, ranking the constraints HeavyHead and RightmostHead independently in Dongolese leads us to a contradiction: RightmostHead must dominate LeftmostHead when heavy syllables are present, yet LeftmostHead must dominate RightmostHead when they are absent. Conjoining HeavyHead and RightmostHead enables us to express the dependency that exists for heads between the properties of syllable weight (HeavyHead) and position in the string (RightmostHead). This dependency also affects the evaluation of the RightmostHead constraint, which is conditioned by its conjunction with HeavyHead, such that only potential head-bearers (heavy syllables) count for its evaluation. We have shown that this must be the case as the criterion of minimal violation does not satisfy RightmostHead at the expense of LeftmostHead when there are no heavy syllables present in the string.

The findings that constraints may be conjoined, and that conjuncts may be ranked with respect to one another indicate that a conjunction may function as a fragment of a constraint hierarchy embedded within a larger hierarchy, and whose evaluation is restricted to a domain whose scope is delimited by a set of microcandidates eligible to serve as the fulcrum of the conjunction.

2. More on the Nature and Limits of Conjunction

In this section we explore further the limits on gradience resulting from relativizing evaluation within a conjunction to the fulcrum. We have argued that linking constraints through conjunction leads to a type of non-gradient evaluation such that the union of all violations against individual conjuncts counts as a single violation of the conjunction as a whole. Thus, in Dongolese, we saw that the conjunction HeavyHead $\wedge^{Head(F)}$ RightmostHead returned at most one violation per candidate. This is not always the case, however: even though conjunction compresses violations, a conjunction may in fact be violated more than once in a single candidate. Below we show, using Diyari as an example, that the number of violations assessed per conjunction corresponds to the number of fulcrums in a candidate form. In other words, just as a constraint like Onset can return up to as many violations as there are syllables in a candidate, a conjunction can return up to *n* violations for a candidate containing *n* fulcrums. Now that most of our crucial assumptions have been introduced, we present our definition of conjunction in (12).

---

[8] For an analysis of Conflation in Cairene Arabic which also relies on stress-head and PrWd alignment, see Crowhurst (1995).

[9] A sonority-based non-conjunctive account of edge/-edge languages has been proposed by Kenstowicz (1994). In Kenstowicz's analysis, FootBin is subordinated to constraints which together impose bilateral alignment on the edges of the *same* foot and word pair, subject to the requirement that non-heads in the foot are less prominent than the head. The result is that Kenstowicz's account permits foot structures very much like the OB foot structures proposed by Hayes (1980/85), including unbounded foot structures such as unu(nέεŋkεgɪd) and (múgosan). Note also that some unbounded trochaic structures are permitted to have heavy heads, a configuration no longer generally accepted in metrical phonology. As Kenstowicz's account makes strong claims about foot structure, and given that we find plenty of evidence for conjunction (see also Hewitt & Crowhurst, in preparation), we are inclined to remain with an analysis which assumes binary feet in particular.

(12) Constraint Conjunction: a set of constraints {A ∧ B ∧ ... n} evaluated relative to a fulcrum (= PCat or GCat), returning *one* violation for the entire conjunction for each fulcrum in the candidate representation.

A more concrete example of a case in which a conjunction incurs multiple violations will be helpful. Assuming (i) a set of conjoined constraints $A \wedge^{MCat} B$, which both share an argument *MCat* (for example, a morpheme); and (ii) inputs containing five instances of *MCat*, evaluation proceeds in the following manner: each *MCat* in the candidate representation is evaluated in parallel by the conjunction. If one (or more) of the conjuncts is violated in a given *MCat*, a single '*' is assessed in the conjunction cell in the tableau. Consider (13), which presents an MCat-by-MCat display in which violations of constraints A and B are registered as 'x' and the violation passed up to the conjunction by each MCat appears as '*'.

(13)

Cand1

Conjunction:		*	*		*	*
Fulcrums		$MCat_\alpha$	$MCat_\beta$	$MCat_\gamma$	$MCat_\delta$	$MCat_\phi$
Constraints:	A	x	x			x
	B		x		x	x

Cand2

Conjunction:		*	*	*	*	*
Fulcrums		$MCat_\alpha$	$MCat_\beta$	$MCat_\gamma$	$MCat_\delta$	$MCat_\phi$
Constraints:	A	x	x			x
	B		x	x	x	x

The tableau format for the information graphically represented in (13) is shown in (14). Violations of the conjuncts A and B are shown with a subscript identifying the fulcrum which incurred the violation. The violations registered for the conjunction as a whole are centered under the ∧ operator. Only the violations passed up to the conjunction are crucial for the evaluation of candidates.

(14)

Cands.	X	A	$\wedge$MCat	B	Y
Cand1 ✓	.....	($^*\alpha$ $^*\beta$ $^*\phi$)	* * * *	($^*\beta$ $^*\delta$ $^*\phi$)	.....
Cand2	.....	($^*\alpha$ $^*\beta$ $^*\phi$)	* * * * *!	($^*\beta$ $^*\gamma$ $^*\delta$ $^*\phi$)	.....

We use this notation below in our analysis of Diyari.

3. Templatic Conjunction in Diyari

In this section we examine evidence from the Australian language Diyari (Austin 1981), which exhibits an unusual interaction between morphology and prosody. Diyari presents another case for conjunction, but differs from Dongolese in that a constraint conjunction is evaluated across several fulcrums in a single candidate form, resulting in multiple violations of the conjunction.

In Diyari, every morpheme of at least two syllables begins with a bisyllabic foot, while monosyllabic morphemes are never stressed (e.g. *púludu* 'mud', *ŋ ándawàlka* 'to close', and *púludu-ni-màta* 'mud-LOC-IDENT'; Austin 1981:31). In other words, foot boundaries are co-located with morpheme boundaries in Diyari, subject to a minimum size constraint on the morpheme. The problem for Diyari lies in accounting for the unusually intimate relationship between foot and morpheme structure; in most languages foot-building is not restricted by morpheme boundaries as in Diyari.[10]

The Optimality Theoretic solution we propose to these problems, building on proposals by P&S and M&P (1993b), makes use of *templatic constraints* which impose requirements of bilateral alignment on the edges of grammatical and prosodic categories (e.g. morphemes and prosodic words). Our proposal is that such templatic constraints are conjunctions of Alignment constraints. The metrical system of Diyari requires the high-ranking conjunction of Alignment constraints in (15a). This templatic conjunction is crucially ranked below the *FootBin(σ)* constraint (15b), which requires feet to dominate exactly two syllables.[11]

(15) a. Align (Morpheme, L, Foot, L) $\wedge$ Align (Morpheme, R, Foot, R)
b. FootBin(σ): A foot must dominate two syllables.

Before proceeding with our analysis of Diyari under the conjunctive approach, we first discuss the nature and formalization of templatic relations and the configuration required for testing whether two Alignment constraints are in a conjunctive relation or not.

3.1 Testing Templatic Alignment Relations

Templatic constraints were originally conceived by M&P (1986) to establish correspondences between morphological and prosodic categories. An example is found in M&P's (1986:38-9) analysis of reduplication in Manam: *Reduplicative Morpheme = Foot* (e.g. *salaga > salagalaga*). In the OT literature, P&S propose the existence of templatic constraints which establish a correspondence between a lexical category and a prosodic category: *LexCat = PCat*. More recently, M&P (1993b) argue that the effects of prosodic templates follow from the requirements of independent Alignment constraints, as in (16), which enforce correspondences between the *edges* of the relevant categories. The formal definition of Alignment constraints appears in (17).

(16) RED = Foot: Align (RED, L, Foot, L), Align (RED, R, Foot, R)

(17) Generalized Alignment (M&P 1993b:2):
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 (Prosodic and Grammatical categories)
Edge1, Edge2 $\in$ {Right, Left}

The "Align" operator takes four arguments, two constituents 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 appropriate edges coincide."

10 Derivational approaches to Diyari responded by defining the cyclic application of structure building rules in an unusual manner (Poser 1989, Hewitt 1992). Specifically, it was necessary either to metrify each morpheme 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.

11 This is a modification of the original *FootBin* constraint of P&S:47 which only requires binarity to exist on one of two levels (syllabic or moraic). (See Hewitt 1994 for similar proposals based on Yupik.)

North East Linguistics Society, Vol. 26 [1996], Art. 9

Templatic alignment constraints, like all other constraints, are in principle violable and are satisfied as best they can be, in competition with higher-ranking constraints in the system. If templatic Alignment constraints are fully independent, then the OT evaluation criterion of minimal violation should provide evidence for this independence. That is, the M&P (1993b) position predicts that when it is not possible to satisfy both Alignment constraints simultaneously, it will be better to satisfy one at the expense of the other. If the outcome is something other than that predicted by independent ranking and minimal violation criterion, then the relationship between templatic Alignment constraints is something which cannot be characterized by OT at present.

In order for templatic constraints, which require the construction of a particular prosodic entity, to assert themselves they must dominate the constraint **Struc(P)* in (18) (Zoll 1993), which militates against the generation of structure not represented in inputs. If *Struc(P) dominated the templatic Alignment constraints the appearance of the prosodic category to satisfy the template would never be optimal (modulo the position of other constraints in a given system).[12]

(18) *Struc(P): Avoid prosodic structure.

Below, we use schematic examples below to show how the evaluation criterion of minimal violation can expose the relationship between Alignment constraints. Consider the hierarchy in (19) in which constraints enforcing right and left alignment between MCat and PCat are independently ranked, though neither outranks the other.

(19) Faithfulness » Align (MCat, L, PCat, L), Align (MCat, R, PCat, R) » *Struc(P)

In (20) we show a system in which a prosodic category can be stretched to fit a morphological string. Possible candidates are shown in (20a-d). As the tableau in (20e) shows, candidates (20a) and (20b) both satisfy the Alignment constraints, and *Struc(P) chooses between them, selecting the candidate with the fewest PCats.

(20) Candidate set:

```
     PCat                 PCat  PCat            PCat                     PCat
    /_______\             /___\ /__\            /__\                     /__\
a. {α...β δ...γ}MCat  b. {α...β δ...γ}MCat  c. {α...β δ...γ}MCat  d. {α...β δ...γ}MCat
```

e.	Align (MCat L PCat L)	Align (MCat R PCat R)	*Struc(P)
(20a) ✓			*
(20b)			* *!
(20c)		*!	*
(20d)	*!		*

This outcome is exemplified by many languages in which a PCat, the prosodic word; is coextensive with an MCat, the grammatical word.

The opposite outcome results with inputs containing more instances of the relevant MCat; we illustrate with the candidate set in (21a-d). Here the dominating Alignment

12 We assume that the Faithfulness constraints (i.e. constraints in the *Parse-family*, which forbid underparsing, as well as constraints such as *MSeg*, and *MMora*; (M&P 1994), which require that every segment and mora, respectively, be morphologically affiliated) are undominated in Diyari, so that the [illegible]nditions is blocked.

constraints force H-Eval to reject candidate (21a) in favor of (21b) which has multiple prosodic categories, as this candidate best satisfies the Alignment constraints.

(21) Candidate set:

```
      PCat                  PCat  PCat            PCat                        PCat
    /________\             /___\ /___\           /___\                       /___\
a. {α...β}{δ...γ}MCat  b. {α...β}{δ...γ}MCat  c. {α...β}{δ...γ}MCat  d. {α...β}{δ...γ}MCat
```

e.	Align (MCat L PCat L)	Align (MCat R PCat R)	*Struc(P)
(21a)	*!	*	*
(21b) ✓			* *
(21c)	*!	*	*
(21d)	*!	*	*

In order to test whether or not the relationship of the templatic Alignment constraints is conjunctive, it is necessary to have a dominating constraint which forces a mismatch between the categories involved in the templatic relationship. This can occur when a dominating constraint governing the size of the prosodic category is present and the form of the morphological category leads to violations of that constraint. These are exactly the circumstances we find in Diyari.

3.2 Stress Assignment in Diyari: Morpheme=Foot

In this section we examine the placement of feet in Diyari (Australia) based on analyses in Austin (1981) and Poser (1986) and argue that the generalizations should be expressed in OT through a conjunction of Alignment constraints capturing a templatic correspondence between MCat, a morpheme, and PCat, a foot.

3.2.1 Basic generalizations and analysis

Austin (1981:30-31) tells us that primary stress in Diyari is word-initial, assigned to the first syllable of the root, while secondary stress falls on the third syllable of quadrisyllabic morphemes, and on the initial syllable of all suffixes of two syllables or longer. In essence, the syllabic length of a morpheme determines whether it has stress or not: morphemes of two or more syllables are stressed, while monosyllabic morphemes are never stressed. Examples demonstrating these patterns appear in (22).

(22)				
	a. káṇa	'man'	e. púlʸudu-ṉi-màṯa	'mud-LOC-IDENT'
	b. pínadu	'old man'	f. pínadu-wàṛa	'old man-PLURAL'
	c. ŋándawàlka	'to close'	g. káṇa-wàṛa	'man-PLURAL'
	d. máḍa-ḷa-ṉi	'hill-char-LOC'	h. ṇánda-na-màṯa	'hit-PART-IDENT'

The important generalization for us is that every Diyari morpheme of two or four syllables is fully parsed into bisyllabic feet.[13] The account we propose here relies on the conjunction of Alignment constraints in (23) which establishes a templatic correspondence

[13] There is only one quadrisyllabic suffix in Diyari *yatimayi* 'optative'. Austin does not give examples using this morpheme where stress is marked, but as he does not note any oddity regarding stress we assume that there is a secondary stress on [ma].

between morphemes and feet (repeated from (15a); we abbreviate the conjuncts henceforth as M-F-L and M-F-R).[14] The fulcrum of the conjunction is the morpheme.

(23) Align (Morpheme, L, Foot, L) $\wedge^{Morph}$ Align (Morpheme, R, Foot, R)

The tableau in (24) shows that the conjunction in (23) is unviolated in forms containing only even-syllabled morphemes, since both edges of every morpheme can be properly aligned.[15] Note that foot-building is achieved at the expense of *Struc(F), the member of the *Struc(P) family we require for Diyari, which must therefore be ranked below the conjunction in the hierarchy.

(24) /{kana}$_\alpha$-{wara}$_\beta$/ and /{ŋandawalka}$_\alpha$/

Candidates	M-F-L	$\wedge$Morph	M-F-R	*Struc(F)
a. (káṇa)-(wàṛa) ✓				* *
b. (káṇa)-waṛa	(*$_\beta$)	*!	(*$_\beta$)	*
c. kaṇa-(wáṛa)	(*$_\alpha$)	*!	(*$_\alpha$)	*
d. (ŋánda)(wàlka) ✓				* *
e. (ŋánda)walka		*!	(*$_\alpha$)	*
f. ŋanda(wálka)	(*$_\alpha$)	*!		*

The forms analysed in (24) do not make the argument for conjunction, as in these cases, ranking the Alignment constraints nonconjunctively would yield the same results. The argument turns on forms such as *ŋánda-na-màṯa* and *máḏa-ḻa-ṉi*, which contain morphemes of one syllable. Monosyllabic morphemes are never footed, due to the high-ranking (in fact, undominated) status of FootBin(σ) in (15b).[16] The crucial evidence for conjunctive ranking is that even when two monosyllabic morphemes occur in sequence, they are not footed. Candidates containing morphemes of one syllable, then, always violate the conjunction in (23), as shown in tableau (25).

---

14 Derivational accounts of the Diyari pattern have proposed cyclic algorithms (Poser 1989, Hewitt 1992), while within OT Crowhurst (1994b) has proposed a constraint *Tautomorphemic Foot*, $*_F[\sigma\ _M[\ \sigma]$, which assesses a violation if a foot spans a morpheme boundary. While Crowhurst's constraint is descriptively adequate for Diyari, it incurs the heavy cost in formalization of all such negative alignment constraints, since determining existence of non-edge elements within a category (foot) requires a more powerful search algorithm. Furthermore, it is not possible to extend this approach to cover prosodic word formation in Yidin^y, which has a similar descriptive generalization (see Hewitt & Crowhurst, in preparation).

15 We do not seriously consider candidates with no foot at all. In addition to violating the conjunction in (23), they also violate the requirement that the PrWd contain a head. The primary status of the initial stress in Diyari is accounted for by the high-ranking status of the constraint Align (Head(PrWd) L PrWd L), which requires left-alignment between the head of the PrWd and the Head foot of the PrWd (i.e. Head(PrWd)).

16 Clearly, FootBin(σ) dominates another constraint requiring that all syllables be dominated by feet. We assume that unfooted syllables are linked to the PrWd.

(25) /{maḍa}$_{\alpha}${ḻa}$_{\beta}${ṉi }$_{\gamma}$/ and /{ṇanda}$_{\alpha}${na}$_{\beta}${maṯa}$_{\gamma}$/

Candidates	FtBin(σ)	M-F-L	$_\wedge$Morph	M-F-R	*Struc(F)
a. (máḍa)-ḻa-ṉi ✓		(*β *γ)	* *	(*β *γ)	*
b. (máḍa)-(ḻà-ṉi)		(*β)	* *	(*γ)	* *!
c. (máḍa)-(ḻà)-(ṉi)	*! *		*		* * *
d. (ṇánda)-na-(màṯa) ✓		(*β)	*	(*β)	* *
e. (ṇánda)-na-maṯa		(*β *γ)	* *!	(*β *γ)	*
f. (ṇánda)-(nà-ma)ṯa		(*γ)	* *!	(*β *γ)	* *
g. (ṇánda)-(nà)-(màṯa)	*!				* * *

The candidates in (25) which violate top-ranked FootBin(σ) are excluded immediately. The choice between (25d,e,f) is straightforward, since (25d) violates the conjunction minimally. However, each the competing candidates in (25a,b) contains two violations for the templatic conjunction. (This is possible because the morpheme is the fulcrum of the conjunction in (23); therefore, each of the monosyllabic morphemes in *máḍa-ḻa-ṉi* violates the conjunction.) Thus, the decision between them falls to *Struc(F).

If the templatic Alignment constraints were ranked independently, we would expect (25b), and not (25a) to be optimal, as the secondary stress foot in (25b) lead to fewer violations of the Alignment constraints individually. This is shown in the tableau in (26).

(26)

Candidates	FtBin(σ)	M-F-L	M-F-R	*Struc(F)
a. (máḍa)-ḻa-ṉi		* *	*! *	*
b. (máḍa)-(ḻà-ṉi) ✘		*	*	* *
c. (máḍa)-(ḻà)-(ṉi)	*! *			* * *

It should be clear that regardless of which constraint is dominant, M-F-L or M-F-R, a nonconjunctive account incorrectly selects *(máḍa)-(ḻà-ṉi) as the optimal candidate.[17]

Trisyllabic roots, like monosyllabic morphemes, are bound to violate the templatic conjunction, in order to satisfy FootBin(σ). Yet, all trisyllabic roots bear initial primary stress. The primary status of the leftmost stress in Diyari can be accounted for by ranking highly the constraint Main-Stress-Left in (27), which requires that the head of the prosodic word be left-aligned within its domain.

(27) Main-Stress-Left: Align (Head(PrWd) L PrWd L)

The facts suggest that Main-Stress-Left is undominated in Diyari. Crucially, (27) outranks the templatic conjunction to force an initial foot in a trisyllabic root, in violation of the conjunction. As FootBin(σ) also dominates the conjunction, this foot cannot be stretched to encompass the third syllable of the root, nor can a monosyllabic foot be constructed to properly align the root's right edge. The final version of the hierarchy required for Diyari is shown in (28). The tableau for *púḍudu-ṉi-màṯa* is shown in (29).

(28) Main-Stress-Left » FootBin(σ) » M-F-L $_\wedge$Morph M-F-R » *Struc(F)

---

17 If the templatic *Alignment* constraints are ranked independently, but are both dominated by *Struc(F), then we arrive at the attested form *máḍa-ḻa-ṉi*. However, ranking *Struc(F) so highly also predicts the absence of secondary stresses in other forms.

(29) /{puludu}$_{\alpha}$-{ni}$_{\beta}$-{mata}$_{\delta}$/

Candidates	Main-Stress-L	FtBinσ	M-F-L	$_{\wedge}$Morph	M-F-R	*Struc(F)
a. (púlu)du-ni-(màta) ✓			(*$_{\beta}$)	* *	(*$_{\alpha}$ *$_{\beta}$)	* *
b. (púlu)(dù-ni)-(màta)			(*$_{\beta}$)	* *	(*$_{\alpha}$)	* * *!
c. (púludu)-ni-(màta)		*!	(*$_{\beta}$)	*	(*$_{\beta}$)	* *
d. (púlu)du-(nì)-(màta)		*!		*	(*$_{\alpha}$)	* * *
e. (púludu)-(nì)-(màta)		*! *				* * *
f. puludu-ni-(máta)	*!		(*$_{\alpha}$ *$_{\beta}$)	* *	(*$_{\alpha}$ *$_{\beta}$)	*
g. pu(lúdu)-ni-(màta)	*!		(*$_{\alpha}$ *$_{\beta}$)	* *	(*$_{\beta}$)	* *
h. (púlu)(dù)-ni-(màta)		*	(*$_{\beta}$)	*	(*$_{\beta}$)	* * *

The candidates in (29c,d,e) are non-optimal as all contain non-binary feet. Candidates (29f,g) are excluded through violations of Main-Stress-Right. This leaves the final competition to (29a) and (29b). As these candidates are tied with respect to the templatic conjunction (with violations assessed conjunctively), (29a) is selected since it has fewer *Struc(F) violations. Note once again that if the Alignment constraints were independently rather than conjunctively ranked, (29b) would be incorrectly selected as optimal.

Our analysis makes two specific predictions for Diyari. The first is that in a quinquesyllabic root (or suffix) we expect to find a foot at both edges of the morpheme, resulting in initial and penultimate stress.[18] This outcome should be forced by the templatic conjunction, which is satisfied only when either edge of a morpheme is aligned with the same edge of a foot. Our second prediction is that trisyllabic suffixes should be stressless, as to foot a trisyllabic suffix violates the conjunction, and the presence of a foot in such a case would not be required by Main-Stress-Right. This prediction is untestable as there are no trisyllabic suffixes listed in Austin (1981). The absence of trisyllabic suffixes is of interest and could be viewed as evidence, especially as both two and four syllable suffixes exist; however it is impossible to rule out an accidental gap interpretation.

Before concluding, we comment briefly on other ways in which templatic constraints have been viewed, the notions *GCat is a PCat*, *GCat=PCat*, and *GCat is the content of PCat*. Following Ito & Mester (1995) 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; as long as a Path exists between the foot node and all the contents of a morpheme, the relation holds (it is possible for part of the 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 (ŋánda)(wàlka), in which the morpheme's edges are aligned

18 Austin lists a single quinquesyllabic root, *wintaranaya* 'how long', in the glossary to his grammar, but does not mark stress. While this form was likely historically morphologically complex, the evidence for where the boundary may have been located is conflicting. Austin cites the form *winta* 'when', implying that *ranaya* is independent. However, [r] doesn't occur word-initially, nor initially in bisyllabic or longer suffixes. This would argue for any morphemic split to be after the [ra]. Additional support for this view is the fact that [r] does not occur in the onset of the third syllable in quadrisyllabic roots, which would lead us to the generalization that [r] is banned foot-initially. (See Hewitt 1992 for discussion on the distribution of consonants in Diyari with respect to stress.) These considerations suggest that *wintaranaya* is apt to fulfill our predictions regarding stress, with a secondary stress on the penultimate syllable.

with the edges of different feet. The advantage of formalizing Diyari's morpheme-to-foot correspondence in terms of Alignment constraints is that nothing in Generalized Alignment theory forces a unique relationship between a single morphological category and a single prosodic category (e.g. morphemes and feet) as long as the edges of the universally quantified argument (in our analysis, the morpheme) are properly aligned.

4. Conclusion

In this paper we have argued that OT must allow a third type of relation between constraints--the relation of conjunction. Thus, a pair of constraints in an OT grammar may be in one of three possible relationships:

(30)	A » B	ranked
	A, B	unranked
	$A \wedge^{fulcrum} B$	conjoined

The evaluation criterion of minimal violation holds between constraints in the *ranked* and *unranked* relations, but does not hold directly between constraints which are *conjoined*. Constraints in a conjunctive relationship do not exhibit the expected gradient interpretation of violations; rather, they show either a narrower form of gradience or complete non-gradience in their evaluation. The gradient evaluation of a conjunction is dependent upon the fulcrum of the conjunction (the argument shared by the constraints) and the number of fulcrums in a given candidate representation. The fulcrum defines the domain for the evaluation of the conjoined constraints, and each fulcrum may return at most a single violation for the conjunction. The non-gradient evaluation of conjoined constraints follows from the logical nature of conjunction: a conjunction is false whenever one its conjuncts is false, and it does not become *more* false if more than one conjunct is false. A conjunction returns a non-gradient evaluation of a given candidate whenever there is only a single fulcrum in the candidate, if there is more than one fulcrum then a conjunction may return more than a single violation, but there is always a one-to-one relation between the number of possible violations and the number of fulcrums in a given candidate.

Our case for recognizing constraint conjunction in OT turned on showing that there exist languages where the criterion of minimal violation does not hold between constraints that have been claimed to capture various patterns. We demonstrated that this is true for the assignment of metrical structure in Diyari and in Dongolese Nubian. In each of these cases it has been possible to capture the relevant generalizations by defining a new relation within which the requirements of familiar constraints can be expressed.

References

Archangeli, D. & D. Pulleyblank (1994) *Grounded Phonology*, MIT Press, Cambridge, MA.

Armbruster, C.H. (1960) *Dongolese Nubian: A Grammar*. Cambridge Univ. Press, Cambridge.

Armbruster, C. H. (1965) *Dongolese Nubian: A Lexicon*. Cambridge Univ. Press, Cambridge.

Austin, P. (1981) *A Grammar of Diyari, South Australia*, Cambridge Univ. Press, Cambridge.

Crowhurst, M.J. (1991) *Minimality and Foot Structure in Metrical Phonology and Prosodic Morphology*, PhD. diss. University of Arizona, distributed (1993) *IULC*.

Crowhurst, M.J. (1994a) "Foot Extrametricality and Template Mapping in Cupeño, *NLLT* 12, 177-201.

Crowhurst, M.J. (1994b) "Prosodic Alignment and Misalignment in Diyari, Dyirbal, & Gooniyandi: An Optimizing Approach", *WCCFL 13*, pp. 16-31.
Crowhurst, M.J. (1995) "An Optimal Alternative to Conflation", ms. UNC-CH.
Dixon, R.M.W. (1972) *The Dyirbal Language of North Queensland*, Cambridge Univ. Press, Cambridge.
Hayes, B. (1980/5) *A Metrical Theory of Stress Rules*. PhD. diss. MIT (Published by Garland, 1985).
Hewitt, M.S. (1992) *Vertical Maximization in Metrical Theory*, PhD. diss. Brandeis Univ.
Hewitt, M.S. (1994) "Deconstructing Foot Binarity in Koniag Alutiiq", ms. UBC.
Hewitt, M.S. & M.J. Crowhurst (in preparation) "Constraint Cunjunction in Optimality Theory", ms. Brandeis/UNC-CH.
Itô, J. & A. Mester (1995) "Realignment", ms. UCSC.
Kenstowicz, M. (1994) "Sonority-Driven Stress", ms. MIT.
McCarthy, J.J. & A.S. Prince (1986) "Prosodic Morphology" ms. UMass & Brandeis.
McCarthy, J.J. & A.S. Prince (1993a) "Prosodic Morphology 1", ms. UMass & Rutgers.
McCarthy, J.J. & A.S. Prince (1993b) "Generalized Alignment", ms. UMass & Rutgers.
McCarthy, J.J. & A.S. Prince (1994) "The Emergence of the Unmarked", ms. UMass & Rutgers.
Poppe, N. (1951) *Khalkha-Mongolische Grammatik*. Franz Steiner Verlag, Wiesbaden.
Poser, W. (1989) "The Metrical Foot in Diyari" *Phonology* 6, 117-148.
Prince, A.S. & P. Smolensky (1993) "Optimality Theory", ms. Rutgers Univ. and the Univ. of Colorado at Boulder.
Smolensky, P. (1993) "Harmony, Markedness, and Phonological Activity", handout from the ROW, October 23.
Street, J.C. (1963) *Khalkha Structure*. Indiana Univ. Press, Bloomington.
Zoll, C. (1993) "Directionless Syllabification and Ghosts in Yawelmani", ms. UC Berkeley.

Mark S. Hewitt
Brandeis University
Department of Psychology
Waltham, MA
02254
hewitt@binah.cc.brandeis.edu

Megan J. Crowhurst
University of North Carolina
318 Dey Hall 014A
CB # 3155
Chapel Hill, NC 27599
mjcrowhu@email.unc.edu