

# Prosodic Morphology

Constraint Interaction and Satisfaction

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## Acknowledgments

We are grateful to Paul Smolensky for wide-ranging discussion of many key theoretical points; to Robert Kirchner and Lisa Selkirk for discussion of related issues; to Henrietta Hung and Suzanne Urbanczyk for a thorough reading of an early draft of this work, and to Laura Walsh and Zvi Gilbert for an equally thorough reading of the final draft; to Vieri Samek-Lodovici and Cheryl Zoll and to Paula Baird, Mary Clark, Amalia Gnanadesikan, Jóhannes Jónsson, Sam Rosenthal, Tim Sherer, Laura Walsh, and Draga Zec for comments on preliminary versions of the analysis; and to Junko Ito, Armin Mester, and Jaye Padgett for a careful critique of an oral presentation. We are also indebted to audiences at Brandeis University, Cornell University, Harvard University, Rutgers University, the University of Pennsylvania, UC Santa Cruz, and University of Wisconsin, especially to Akin Akinlabi, Andy Black, Jonathan Bobaljik, Gene Buckley, Tony Bures, Andrea Calabrese, Jill Carrier-Duncan, Abby Cohn, Beverley Goodman, Tom Green, Jane Grimshaw, Morris Halle, Bill Idsardi, Greg Iverson, Michael Kenstowicz, Paul Kiparsky, Tony Kroch, William Labov, Mark Liberman, Brian McHugh, Marcy Macken, Ad Neeleman, Rolf Noyer, Mark Steedman, and Irene Vogel. Neither jointly nor severally should these individuals be held responsible for our errors.

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## Introduction to ROA Version, November 2001

This document was originally circulated in April 1993 and has been available as Technical Report #3 of the Rutgers University Center for Cognitive Science. The current version is essentially identical to RuCCS-TR-3, with a few minor corrections. These prefatory remarks offer a brief orientation to the principal themes of the work and pointers to some of the literature that carries them forward.

A central formal development is the notion of *correspondence* (see page 67). Originally proposed as a relation between a stem and the reduplicative affix attached to it, correspondence has been extended to provide a general basis for faithfulness theory (McCarthy and Prince 1995, 1999). Other works containing significant applications or extensions of correspondence theory include — but are by no means limited to — Alderete (1998, 2001a, 2001b), Beckman (1995, 1997, 1998), Benua (1997), Bresnan (to appear), Broselow (2001), Burzio (1997), Casali (1996, 1997), Causley (1997, 1999), Crosswhite (1998), de Lacy (1999b, 1999c), de Lacy and Kitto (1999), Hume (1998), Ito, Kitagawa, and Mester (1996), Ito and Mester (1997, 1999), Keer (1999), Lamontagne and Rice (1995), Orgun (1996a), Rose and Walker (2001), Spaelti (1997), Struijke (1998, 2000a, 2000b), Urbanczyk (1996), Woolford (2001a), and Zoll (1996).

Another theme is the importance of constraints on the *alignment* of prosodic and morphological constituents (see §§4.2, 4.3). The original idea comes from Prince and Smolensky (1991), building on the edge-based theory of Chen (1987) and Selkirk (1986). Alignment is formalized and various applications are presented in McCarthy and Prince (1993). Further applications and refinements in phonology have been numerous; Kager (1999: 117-124) provides a useful and accessible overview. Outside phonology proper, alignment has also been applied to the phonology/syntax interface (Selkirk 1995, Truckenbrodt 1995), to focus (Choi 1996, 2001, Costa 1998, 2001, Grimshaw and Samek-Lodovici 1995, Samek-Lodovici 1996, 1998), and to various syntactic phenomena, especially the basic theory of phrase structure (Grimshaw 2001b) and clitics (Anderson 1996a, 1996b, 2000, Grimshaw 2001a, Legendre 1998, 1999, 2000, 2001, Peperkamp 1997, van der Leeuw 1997, Woolford 2001b).

Chapter 3 and the Appendix introduce the idea of *stratal organization in OT*. Each stratum is a distinct OT grammar — that is, it is a distinct ranking of the constraints of UG. (See pp. 167ff. for discussion of some possible limits on how strata can differ.) Like the strata of Lexical Phonology, these strata are linked to the morphological system, but the OT strata consist of constraint hierarchies rather than rules, with the output of one stratum submitted as input to the next. Stratal OT receives further study in the following works, among others: Black (1993), Bermúdez-Otero (1999), Cohn and McCarthy (1994/1998), Hale and Kisser (1998), Hale, Kisser, and Reiss (1998), Ito and Mester (2002), Kenstowicz (1995), Kiparsky (2002a, 2002b), McCarthy (2000b), Potter (1994), Rubach (2000), and many of the contributions to Hermans and van Oostendorp (1999) and Roca (1997). For alternative approaches to some of the phenomena taken to motivate stratal OT, see Archangeli and Suzuki (1997), Benua (1997), Burzio (1994), Crosswhite (1998), Ito, Kitagawa, and Mester (1996), Ito and Mester (1997), Kager (1997), Kenstowicz (1996, 1997), Kraska-Szlenk (1995), McCarthy (1999, 2002), and Orgun (1996).

Chapters 5 and 7 work deal primarily with the *theory of templates*. The theme here is using the interactive character of Optimality Theory, rather than parochial stipulation, to derive predictions about the range of possible linguistic patterns. These chapters present our initial efforts toward the elimination of prosodic templates as primitives of the theory of Prosodic Morphology. The lectures transcribed in McCarthy and Prince (1994b) are a kind of manifesto

of this research program, called *Generalized Template Theory*. In those lectures and in McCarthy and Prince (1994a, 1995, 1999), we argue that there are no templates *per se*; rather, all putative templatic effects are a consequence of independently-motivated constraints on phonology, morphology, and their interface. Other works contributing to this program include *inter alia* Alderete et al. (1999), Carlson (1998), Chung (1999), de Lacy (1999a, 2002), Downing (1994, 1998a, 1998b, 1999), Gafos (1998), Hargus and Tuttle (1997), Hendricks (1999), Horwood (2001), Ito, Kitagawa, and Mester (1996), McCarthy (2000a, 2000b), Pater and Paradis (1996), Spaelti (1997), Struijke (1998, 2000a, 2000b), Urbanczyk (1996, 1999), Ussishkin (1999, 2000), Walker (2000), and Yip (2001). (Cf. Hyman and Inkelas 1997, Inkelas 1999 for a critical view.)

The theory of Prosodic Morphology seeks to derive the observed properties of morphology/phonology dependencies from independent, general principles. As much as possible, maybe entirely, the goal is to eliminate Prosodic-Morphology-specific mechanisms from the theory and from grammars. The phenomena and regularities of Prosodic Morphology in general and of reduplication in particular should emerge from general properties of morphology, phonology, and their interface. This work is intended as a step toward that goal.

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# 1. Introduction

Prosodic Morphology (McCarthy and Prince 1986 *et seq.*) is a theory of how morphological and phonological determinants of linguistic form interact with one another in a grammatical system. More specifically, it is a theory of how prosodic structure impinges on templatic and circumscriptional morphology, such as reduplication and infixation. There are three essential claims:

## (1) Principles of Prosodic Morphology

### a. Prosodic Morphology Hypothesis

Templates are defined in terms of the authentic units of prosody: mora ( $\mu$ ), syllable ( $\sigma$ ), foot (Ft), prosodic word (PrWd).

### b. Template Satisfaction Condition

Satisfaction of templatic constraints is obligatory and is determined by the principles of prosody, both universal and language-specific.

### c. Prosodic Circumscription

The domain to which morphological operations apply may be circumscribed by prosodic criteria as well as by the more familiar morphological ones.

In short, the theory of Prosodic Morphology says that templates and circumscription must be formulated in terms of the vocabulary of prosody and must respect the well-formedness requirements of prosody.

But this picture is incomplete in various crucial respects. With most work in contemporary phonological theory, it underarticulates the role of well-formedness constraints; knowing *that* they are obeyed is not the same as knowing *how* they are obeyed and *why* they may be violated under other conditions. A more local problem, which we will document extensively below, is that the vocabulary and constraints of prosody can be active in morphology that is neither templatic nor circumscriptional, where the principles of Prosodic Morphology are without force. Thus, the standard theory is incomplete in a significant way. Finally, there are cases, also discussed below, where the standard theory is empirically wrong — cases where, for example, templatic constraints are *not* satisfied obligatorily or infixation *cannot* be analyzed by the circumscription of prosodic constituents.

Prince and Smolensky's (1991 *et seq.*) Optimality Theory is a completely general response to the first of these issues, the underarticulation of the role of well-formedness constraints throughout phonological theory. Chapter 2 lays out and illustrates the fundamental concepts of Optimality Theory at length, but informally they are:

## (2) Principles of Optimality Theory

### a. Violability.

Constraints are violable; but violation is minimal.

### b. Ranking

Constraints are **ranked** on a language-particular basis; the notion of minimal violation is defined in terms of this ranking.

c. Inclusiveness

The constraint hierarchy evaluates a set of candidate analyses that are admitted by very general considerations of structural well-formedness. There are no specific rules or repair strategies.

d. Parallelism

Best-satisfaction of the constraint hierarchy is computed over the whole hierarchy and the whole candidate set. There is no serial derivation.

All of these aspects of Optimality Theory are called on crucially in the analyses we present below, and indeed one goal of this work is to demonstrate how Optimality Theory can lead to illuminating analyses of otherwise recalcitrant data.

But our central theme is to show how combining the insights of Prosodic Morphology with those of Optimality Theory can provide a more complete understanding of how prosody and morphology interact. Our proposals are presented and justified extensively in chapter 7, but in brief they are:

(3) Proposals

a. Ranking

In all cases of prosodic morphological phenomena, prosodic constraints dominate morphological ones.

b. Constraint Typology

Templatic and circumscriptive constraints are members of a broad family of constraints on the *alignment* of morphological and prosodic categories.

c. Template Satisfaction and Circumscription

The satisfaction of templatic and circumscriptive requirements is by evaluation of an inclusive set of candidates, not by rules or repairs. The candidates are assessed in parallel.

d. Violability

Templatic and circumscriptive constraints, like all other constraints, are violable if dominated.

Proposal (3a) is the fundamental characterization of how prosody and morphology interact in Prosodic Morphology, but it generalizes this interaction to prosodic morphological phenomena that are neither circumscriptive nor templatic. Proposal (3b) generalizes templatic and circumscriptive constraints to a broader class of constraints governing the interface between prosody and morphology. (Examples of such constraints will be found throughout, starting in §4.2.) This proposal, by identifying templatic and circumscriptive requirements as prosody/morphology alignment constraints, directly entails the *prosodic* basis of templates and circumscription embodied in the Prosodic Morphology Hypothesis and Prosodic Circumscription of Domains. Proposals (3c) and (3d) establish that templatic and circumscriptive constraints are like all other constraints within Optimality Theory: they evaluate sets of candidates, considered in parallel, and they may be violated in particular grammars.

Novel theoretical schemes, however appealing on *a priori* grounds, can have no claim on our attention unless they are supported by a solid base of empirical results. In chapter 7 we

will present much cross-linguistic evidence for our proposals, but our principal empirical results come from the complex but highly regular system of prosodic phonology and morphology in Axininca Campa, an Arawakan language of Peru. Axininca Campa is the subject of a comprehensive analysis by Payne (1981), from which all of our data come (except as otherwise noted). More recently, it has been trenchantly reanalyzed by Yip (1983), Levin (1985), Itô (1986, 1989), Black (1991a, 1991b), and, in an important body of insightful work, by Spring (1990a, 1990b, 1990c, 1991, 1992). Thanks to these contributors, the analytic and theoretical issues arising in this language are quite sharply defined.

We will present a nearly complete account of the prosodic phonology and morphology of Axininca Campa, laid out as follows. Chapter 3 briefly describes the organization of Axininca Campa morphology and phonology, motivating three levels: Prefix, Suffix, and Word. Chapter 4 analyzes in detail the Suffix-level phonology of Axininca Campa, presenting all of the known constraints on prosodic structure and on the interface between prosody and grammar. Chapter 5 gives a similarly comprehensive account of reduplication in Axininca Campa, relying crucially on many of the results of chapter 4. Chapter 5 concludes with a review of the form and role of the various constraints on the reduplicative affix in this language. Chapter 6 then compares this account of Axininca Campa reduplication with other proposals in the literature, while the Appendix completes the treatment of Axininca Campa by analyzing the most significant Word-level phonological phenomena, stress and velar glide loss.



## 2. Optimality Theory

Grammar is charged with the responsibility of assigning structures to linguistic objects. In phonology this amounts to defining the pair (*underlying-form<sub>i</sub>*, *surface-form<sub>k</sub>*). In much modern work, the overall pairing resolves into a chain of pairs (*input<sub>i</sub>*, *output<sub>j</sub>*) for each lexical level, where *output<sub>j</sub>* stands as input in the next level's pair. A fundamental and much mooted question, given this organization, is exactly *how* the pairing is accomplished: by what principles, formal actions, and deductive maneuvers is a given input to be matched with the correct output?

The original answer, of course, involved the notion of a rewrite rule:

$$(1) \quad A \rightarrow B / C \text{---} D$$

Such a rule examines its *input* for the pattern *CAD*, and if it is found, changes element *A* into *B*, producing an output that is typically subject to further rules of the same type.

Over the course of research since the late 1960's, it has been found repeatedly that linguistic patterning in many areas is actually governed by structural constraints on the output level, constraints which furthermore hold generally across forms that would be processed by many distinct rewrite rules. This result undermines both aspects of the original rule concept. The content attributed to the structural description *CAD* turns out to follow from the general constraints on the language; and the specificities of the structural change *A*→*B* can be dropped in favor of an extremely general imperative to change the representation freely, within certain very broad limits. The prototypical and most spectacular example is the supplanting of classical transformations by Move- $\alpha$  along with a collection of principles of binding, government, and the like. Within phonology one might cite, among many other similar developments, the rise of templatic morphology (McCarthy 1979a, McCarthy and Prince 1986), in which conditions on output shape rather than rules govern the form of morphemes; and the theory of rhythmic adjustment (Lieberman 1975, Lieberman and Prince 1977, Prince 1983, Hayes 1991), in which a single general process of structural mutation is allowed to apply freely, so long as the output meets certain configurational constraints.

Shifting the explanatory burden from input-driven rewrite rules to output constraints changes the way the input-output pairing system must be set up, particularly in phonology. Instead of taking an underlying form — an *input* — and transforming it deterministically step-by-step to its associated output, it is necessary to allow for the generation of a large set of candidate outputs. The candidate set of formal possibilities is submitted to evaluation by the system of well-formedness constraints, which selects the true output from among the candidates. The grammar is configured like this:

$$(2) \quad \begin{aligned} \text{Gen}(in_i) &\rightarrow \{ \text{cand}_1, \text{cand}_2, \dots \} \\ \text{Eval}(\{ \text{cand}_1, \text{cand}_2, \dots \}) &= \text{out}_{\text{real}} \end{aligned}$$

The function *Gen* associates each input with a set of grammatical analyses, typically an infinite set. In the GB family of syntactic theories, *Gen* involves Move- $\alpha$  (applying repeatedly), adjunction, free coindexation, and so on. In phonology, it will involve, for example, construction of many different prosodic parses. The function *Eval* is given by the system of output constraints, and rates the well-formedness of each member of the candidate set.

On the usual view, the output is the form which meets *all* the relevant constraints; it is the “well-formed” candidate. Approaches to phonological constraints based on this assumption

begin with Kisseberth (1970) (cf. Kiparsky (1973b), Haiman (1972), Chomsky and Halle (1968: Chap. 9), Stampe (1973), and Sommerstein (1974) and continue with Bird (1990), Bosch and Wiltshire (to appear), Burzio (1992b), Calabrese (1988), Goldsmith (1990, 1991), Kaye, Lowenstamm, and Vergnaud (1985 et seq.), Kiparsky (1980), Kirchner (1990), Lakoff (in press), Mohanan (in press), Myers (1991), Paradis (1988a, b), Scobbie (1991, 1992), Singh (1987), and Wiltshire (1992), among others.<sup>1</sup> In recent work, however, Prince and Smolensky (1991a, 1991b, 1992, 1993) have argued that the goal of developing a restrictive theory of Universal Grammar can best be served by allowing constraints to be *violated*. On this view, the output will typically fail to meet every constraint, and indeed may violate many constraints many times. Control over violation is achieved by defining the notion of “best-satisfaction” of a system of often conflicting constraints. For a given input, the candidate that best-satisfies the constraint system is termed *optimal* and is by definition the output that the grammar associates with the input. Because of this, the approach goes by the name of Optimality Theory.<sup>2</sup>

The central analytical proposal of Optimality Theory is that constraints are ranked in a hierarchy of relevance. Lower-ranked constraints can be violated in an optimal output form to secure success on higher-ranked constraints. Universal Grammar specifies the set of constraints out of which grammars are constructed, as well as the function Gen that produces the candidate set for each input. Individual grammars are constructed by imposing a ranking on the Universal constraint set, with some setting of parameters and fixing of arguments within the constraints. Interlinguistic variation is to be explained primarily as the result of differences in the ranking of constraints.

We can distinguish four hallmark properties of Optimality Theory:

- (i) **Violability.** Constraints are **violable**; but violation is minimal.
- (ii) **Ranking.** Constraints are **ranked** on a language-particular basis; the notion of minimal violation (or best-satisfaction) is defined in terms of this ranking.
- (iii) **Inclusiveness.** The candidate analyses, which are evaluated by the constraint hierarchy, are admitted by very general considerations of structural well-formedness; there are no specific rules or repair strategies with specific structural descriptions or structural changes or with connections to specific constraints.
- (iv) **Parallelism.** Best-satisfaction of the constraint hierarchy is computed over the whole hierarchy and the whole candidate set.

Optimality Theory rejects the notion that a *constraint* is a phonotactic truth at some level of description. The search for the substantive components of Universal Grammar is therefore not a search for such truths. New possibilities for explanation are opened up, as new kinds of conditions on structure are recognized as legitimate constraints, usable as principles of grammar.

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<sup>1</sup>For a skeptical view of phonological constraints, see Bromberger and Halle (1989).

<sup>2</sup>Besides Prince and Smolensky’s work, other studies in Optimality Theory include Archangeli and Pulleyblank (1991; 1992:340, 349f.), Black (1993), Churchyard (1991), Goodman (in preparation), Hung (1992, in preparation), Itô and Mester (to appear), Itô, Kitagawa, and Mester (1992), Kirchner (1992b, 1992c), Legendre, Raymond, and Smolensky (1993), McCarthy (to appear, in preparation), Mester (to appear), Prince (1991), Rosenthal (in preparation), Samek-Lodovici (1992, 1993), Selkirk (1993), Sherer (in preparation), Yip (1992, 1993), Zec (1992), and Zoll (1992, 1993).

In this section we will first explicate the basic notion of constraint ranking (§2.1), then show how it supports the theory of syllable structure that plays a central role in the analysis of Axininca Campa reduplication (§2.2), and finally we will present the candidate-defining function Gen that will be assumed in the Axininca analysis (§2.3).

## 2.1 Ranking

Let us first consider the notion of constraint-ranking in a mildly abstract setting, then move on to a concrete example. Suppose we have a grammar consisting of two constraints, A and B. The grammar functions to pair underlying forms with surface forms:  $(in_1, out_1)$ ,  $(in_2, out_2)$ , and so on. Suppose we have a certain underlying form  $/in_k/$  which gives rise, via Gen, to a candidate set  $\{cand_1, cand_2\}$ .

If both A and B agree over the candidate set, then there is nothing to say. The optimal candidate — the output associated with  $in_k$  — is just the one that meets both constraints; the suboptimal candidate is the one that fails both of them. The interest increases sharply when the constraints disagree, or *conflict*, on the candidate set. The clearest way to set this out is in tabular form:

### (3) Constraint Conflict $/in_k/$

Candidates	A	B
$cand_1$		*
$cand_2$	*	

Candidate  $cand_1$  meets A but fails B; while  $cand_2$  meets B but fails A.

Suppose now that  $cand_1$  is the correct output form associated with  $/in_k/$ . Constraint A has priority over constraint B, in the sense that when A and B disagree on a candidate-pair, the decision between them is made by A alone. In this case, we will say ‘A dominates B’ and write  $A \gg B$ . With the domination relation specified, we can construct a display that registers how various candidates fare on the hierarchy, a ‘constraint tableau’.

### (4) Constraint Tableau, $A \gg B$ , $/in_k/$

Candidates	A	B
$\text{☞ } cand_1$		*
$cand_2$	* !	

These are the basic conventions:

- Left-to-right column order mirrors the domination order of the constraints.
- Violation of a constraint is marked by \*.
- Satisfaction is indicated by a blank cell.

With these conventions, the constraint tableau plays a role in Optimality Theory analogous to the truth table in propositional logic; it allows one to calculate the outcome in a straightforward but rigorous fashion.

The further notations inscribed in the tableau are included to increase perspicuity:

- The sign ! draws attention to a fatal violation, the one that is responsible for a candidate's nonoptimality. It highlights the point where the candidate in question loses to other more successful candidates.

- The symbol  $\Rightarrow$  draws attention to the optimal candidate.

- Shading emphasizes the *irrelevance* of the constraint to the fate of the candidate. A loser's cells are shaded after the fatal confrontation; the winner's, when there are no more competitors.

Constraints can be directly ranked only when they *conflict*. This occurs when they disagree over a pair of candidates, one of which is in fact optimal. (The other source of meaningful ranking is the transitivity of the domination relation.) Just because constraints conflict over one set of forms doesn't mean, however, that they conflict on every form. Various situations of partial disagreement arise:

(5) Constraint Tableau,  $A \gg B$ , /in<sub>j</sub>/

Candidates	A	B
form <sub>1</sub>		* !
$\Rightarrow$ form <sub>2</sub>		

This represents the same hierarchy  $A \gg B$ , faced with another input in<sub>j</sub>, which underlies a completely different candidate set {form<sub>1</sub>, form<sub>2</sub>}. A is uniform over the set, but B distinguishes them. In this case, the constraint A — though higher-ranked — can make no decision, and the matter is passed on to B. The very same situation arises when all candidate forms *violate* A:

(6) Constraint Tableau,  $A \gg B$ , /in<sub>m</sub>/

Candidates	A	B
candform <sub>1</sub>	*	* !
$\Rightarrow$ candform <sub>2</sub>	*	

Once again, performance on A fails to decide, and B must be consulted. This illustrates a key characteristic of Optimality Theory: simple violation of a constraint is never in itself fatal. Violation is only fatal when there are other competing candidates that pass the constraint. Evaluation is not absolute, but is always relative to the set of possible analyses.<sup>3</sup>

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<sup>3</sup>Paradis's (1988a, b) *Theory of Constraints and Repair Strategies* (TCRS) also recognizes the notion of a constraint conflict, but it plays a different role in the architecture of the theory. TCRS works through serial derivations in which certain designated rules, called *repair strategies*, apply one after the other to correct ill-formed

The general principle of systematic evaluation that lies behind these examples can be characterized from several functionally equivalent perspectives. Thinking in terms of the constraints themselves, one can spell out the evaluation function like this: first evaluate with respect to highest-ranked constraint; if that fails to decide, then evaluate with respect to the rest of the hierarchy (which begins, of course, with the next most highly ranked constraint). Another approach to formalization focuses on the pattern of violations. Define the ‘highest-ranking’ or ‘worst’ violation-mark incurred by a candidate as one associated with the most highly ranked constraint that the form violates. To compare two candidates, compare the highest-ranking violation earned by each. If one’s highest mark is worse than the other’s, it loses. If the worst marks are equivalent, then omit the marks just compared, and repeat the procedure. This approach has been formalized under the name *Harmonic Ordering* (Prince and Smolensky 1993: §3).<sup>4</sup> Any two forms can be compared with respect to a constraint hierarchy, so that evaluation imposes a natural order on the universe of candidates, defining the *harmony* or degree of relative success of each candidate with respect to the others.

When it happens in some candidate set that  $\text{cand}_i$  fares better than  $\text{cand}_j$ , we will write  $\text{cand}_i \succ \text{cand}_j$  for ‘ $\text{cand}_i$  is more harmonic than  $\text{cand}_j$ ’. The optimal candidate stands at the top of this order: it is the output of the grammar, and the harmonic relations among the failed candidates have no grammatical interpretation.<sup>5</sup>

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configurations. The constraints in a language tell the repair strategies when to apply. A constraint conflict occurs when repairing one constraint violation would create a violation of another constraint. For example, among the constraints on segment sequences in Gere are these:  $*\mathcal{O}\mathcal{E}$  and  $*w\mathcal{O}$ , both of which are completely true of the surface (Paradis 1988b:12). Raising  $\mathcal{O}$  to  $\mathcal{O}$  in  $/w\mathcal{O}-\mathcal{E}/$  ‘I make PRO shout’ repairs a violation of  $*\mathcal{O}\mathcal{E}$ , but it creates a violation of  $*w\mathcal{O}$ , so  $*\mathcal{O}\mathcal{E}$  and  $*w\mathcal{O}$  are in conflict in the TCRS sense. Raising must nevertheless take place. Thus, a *constraint conflict* in TCRS is really a conflict between the particular repair strategy triggered by one constraint and the prohibition expressed by another. The issue to be resolved is how to get a repair strategy to apply when its immediate output is surface-bad; that is, how to admit and control temporary deviations from the phonotactics in the course of derivation. In Optimality Theory, by contrast, constraint domination determines which constraint will actually be *true* (or nearest to true) in cases of conflict.

Constraint conflicts in TCRS are adjudicated by consulting a universal principle, the Phonological Level Hierarchy (PLH). According to the PLH, repairs associated with constraints on the well-formedness of higher-level constituents take precedence over constraints on lower-level ones, and, in case of conflicts at the same level of constituency, precedence follows the linear order in which violations are created. Thus, repair of  $*\mathcal{O}\mathcal{E}$  takes precedence over  $*w\mathcal{O}$  in Gere  $/w\mathcal{O}-\mathcal{E}/$ , because the violation of  $*\mathcal{O}\mathcal{E}$  was created by a suffixation rule.

Although constraint conflicts will lead to violations at intermediate stages of the derivation (so Gere underlying  $/w\mathcal{O}-\mathcal{E}/$  becomes intermediate  $/w\mathcal{O}-\mathcal{E}/$ , which violates  $*w\mathcal{O}$ ), constraint violations in the final output are impossible. Derived constraint violations are simply repaired at the next step of the derivation by the repair strategy associated with the (temporarily) violated constraint (so Gere  $/w\mathcal{O}-\mathcal{E}/$  becomes  $g\mathcal{O}-\mathcal{E}$ , removing the violation of  $*w\mathcal{O}$ ). (We are indebted to Robert Kirchner for discussions that clarified this aspect of TCRS.)

<sup>4</sup>The language used here suggests, perhaps misleadingly, a temporal or sequential interpretation; in fact, the definition of best-satisfaction is given recursively, and it is only the practical implementation that shows signs of seriality.

<sup>5</sup>The seductive but potentially confusing term ‘relative well-formedness’ will be eschewed in favor of ‘more harmonic’, preserving the term ‘well-formed’ for use in a strictly absolute sense: the output is well-formed with respect to the grammar, and sometimes we will say that a form meeting a constraint is well-formed with respect to that constraint. The reason for this is to avoid a potentially confusing terminological tangle noted by Prince and Smolensky. Every form produced by Gen from every possible input can be Harmonically Ranked with respect to every other form. It can happen then, that  $\text{cand}_1 \succ \text{cand}_2$ , where  $\text{cand}_1 \in \text{Gen}(in_i)$  and  $\text{cand}_2 \in \text{Gen}(in_j)$  for distinct underlying forms  $in_i$  and  $in_j$ , but nonetheless  $\text{cand}_1$  is **not** optimal although  $\text{cand}_2$  is! In this case, we would have to say that  $\text{cand}_1$  is ‘more well-formed’ than  $\text{cand}_2$ , although it is *ill*-formed and  $\text{cand}_2$  is well-formed. Harmonic

The evaluation theory has a further important consequence. Many constraints admit of *multiple* violations in a given form. (For example, a form might contain a number of onsetless syllables.) The principle of *Harmonic Ordering* entails the desirable result that any single constraint will only be violated minimally in an optimal form.<sup>6</sup> To see this, suppose that the two forms F and G violate the same constraint C. Suppose too that C is the highest-ranked constraint that F and G violate, so it is crucial to compare them. Assume that F incurs a violation-set  $\{***\}_C$  and G a violation-set  $\{*\}_C$  on the constraint C. By the definition of Harmonic Ordering, we compare the worst single violations of F and G — here, one \* from each set. Since this does not decide, we omit this particular violation-mark from consideration and try again. Form G's violation-set for C is emptied, but F's set is not. Form G is therefore the victor, because any other violations it incurs can only be on constraints lower-ranked than C. The notion of Harmonic Ordering defines best-satisfaction in a way that encompasses hierarchical ranking of violations ('violate the lowest-ranked constraint') and nonranking ('violate any single constraint to the least degree possible').

Let us descend now from the mildly abstract to the mildly concrete. A significant phenomenon of Prosodic Morphology is the phonologically-determined placement of affixes; infixation in particular is often determined by phonological conditions (McCarthy and Prince 1986, 1990a). Here we focus on a form of 'edge-oriented' infixation, whereby an affix is situated near the beginning or end of its domain, but not necessarily in outermost position. Optimality Theory can provide a principled explication that has eluded earlier formal approaches. (For further exploration of this and other types of infixation within Optimality Theory and Prosodic Morphology, see §7.)

In Tagalog, for example, the infix *-um-* is located after the onset, if any, of the first syllable of the word:

(7) Distribution of Tagalog *-um-*

<i>Root</i>	<i>um+Root</i>	
aral	um-aral	'teach'
sulat	s-um-ulat	'write'
gradwet	gr-um-adwet	'graduate' (French 1988)

Vowel-initial forms like /aral/ appear as *ʔaral* on the surface.

Prince and Smolensky (1991a, b, 1992, 1993) show how this phenomenon can be understood in terms of constraint interaction. They follow McCarthy and Prince (1986, 1990a) in holding that infixes like *-um-* are to be treated as **prefixes** rather than as some *sui generis* breed of affixal entity. Within Optimality Theory, however, the very notion **prefix** can be defined in terms of a violable constraint: a prefix is an affix appearing in the leftmost possible position in its domain. Other constraints in grammar may entail that 'leftmost possible' is not always identical to 'leftmost'.

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comparison of output forms (from distinct inputs) becomes important in the theory of the lexicon (Prince and Smolensky 1993:§9).

<sup>6</sup>Observe that this notion of minimality is once again entirely relative and does not count up violations in any sense ('this constraint has 4 violations and that is too many'), but merely compares candidates to determine *more* and *less* violation.

The basic observation is that infixal placement of *-um-* results in superior syllable structure. Contrast these alternatives:

$$(8) /um+sulat/ \rightarrow \begin{cases} * .um.su.lat. \\ .su.mu.lat. \end{cases}$$

(Here and throughout, we will indicate syllable edges with periods rather than brackets for reasons of typographical convenience.)

In the illicit, merely prefixed form, the affix introduces a new closed syllable *.um.* into the word. In the correct output, affixation adds only open syllables. We want this very effect to be directly responsible for the placement of the affix. If we succeed, we will have given grammatical force to Anderson's (1972) and Cohn's (1992) suggestion, made in the context of Sundanese, that infixation of VC prefixes has phonotactic motivation. (The technical resources available to these authors did not permit them to construe the observation formally.)

There are then two constraints relevant to infix placement in Tagalog: *EDGEMOST(L/R-edge, φ)*, which holds that the linguistic element φ should be positioned at left/right edges; and *NOCODA*, which governs well-formedness of syllables.

#### (9) Constraints Active in Tagalog Infixation

##### a. *EDGEMOST(L, um)*

The morpheme *um* is located at the left edge; is a prefix.

##### b. *NOCODA*

Syllables are open.

*NOCODA* is the grammatical principle corresponding to the familiar markedness observation (Jakobson 1962:526, Clements and Keyser 1983:29). Violations of *EDGEMOST(L/R,φ)* are reckoned in terms of the distance of φ from the designated edge, where each individual phonological element (segment, say) that intervenes between φ and the edge counts as a distinct violation. This means that *EDGEMOST* will function as a gradient constraint, judging the nearness of φ to the edge of the domain.<sup>7</sup> We assume, as in (9a), that there is a version of *EDGEMOST* for each linguistic element φ, to allow for the obvious possibility that some morphemes might be infixes but other, similar ones might be prefixes or suffixes in the same language.

The key move is now to impose the ranking *NOCODA*  $\gg$  *EDGEMOST(L, um)* on the grammar of Tagalog. The function Gen will produce, for every affix, every possible placement in and around the Base.<sup>8</sup>

Consider the effect on */um+sulat/*. The following tableau records the evaluation of every member of the candidate set with respect to the two-constraint hierarchy:

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<sup>7</sup>The scale of optimal prefix locations implied by *EDGEMOST* can also be defined in terms of proper containment relations on the substrings separating various candidate prefix locations from the left edge of the word. If P is some prefix, B some base, and *wx* and *yz* two partitions of B (so *wx = yz = B*), then *wPx* satisfies *EDGEMOST* more than *yPz* if and only if *w*  $\subset$  *y*.

<sup>8</sup>No harmonic gain would be achieved by dispersing the segments of the affix among the segments of the Base, as the reader may verify. For simplicity, however, we assume that Gen respects the contiguity of the segments in the affix.

(10) /um+sulat/

Candidates	NOCODA	EDGEMOST
. <i>UM</i> .su.lat.	** !	∅
<sup>u</sup> . <i>U</i> . <i>Mu</i> .lat.	*	s
.su. <i>UM</i> .lat.	** !	su
.su.l <i>U</i> . <i>Mat</i> .	*	sul !
.su.la. <i>UMt</i> . <sup>9</sup>	*	sula !
.su.la.t <i>UM</i> .	*	sulat !

Violation of EDGEMOST is shown by listing the string that intervenes between the affix and the initial edge of the domain; each segment could be less perspicuously replaced by a \*.

Because it is dominant, NOCODA definitively rejects all candidates in the set that show more than minimal violation. Most notably, this includes the classically prefixal \**umsulat*. Among the others, the form *sumulat* achieves closest-to-leftmost placement, hence minimal violation of EDGEMOST. It is therefore optimal, as desired.<sup>10</sup>

The behavior of V-initial roots with respect to the constraint hierarchy is equally interesting:

(11) V-initial Roots, from /um+aral/

Candidates	NOCODA	EDGEMOST
<sup>u</sup> <i>U</i> . <i>Ma</i> .ral.	*	∅
.a. <i>UM</i> .ral.	** !	a
.a.r <i>U</i> . <i>Mal</i> .	*	ar !
.a.ra. <i>UMl</i> .	*	ara !
.a.ra.l <i>UM</i> .	*	aral !

Here *um* is optimally positioned as a classical prefix. In absolute initial position, it incurs no more than the minimal possible violation of NOCODA. Two other candidates are also minimally

<sup>9</sup>Of course, this form also violates very fundamental syllable structure constraints that permit only single coda consonants in Tagalog, but we include it for completeness. We continue with this policy below.

<sup>10</sup>Instead of the purely structural constraint NOCODA, a feature-dependent constraint might be called on. In the Ramos (1971) dictionary, *m* is only possible before *p* and *b*, so *m* must be linked to be permitted in coda position (v. Itô 1986, 1989). If linking is excluded for heteromorphemic clusters like \**um-bilih*, this constraint will yield the same results NOCODA. On this view, what is responsible is a Coda-Condition constraint, in the sense of Itô, rather than the general prohibition that rules out all coda segments. Even if this is correct, the argument would proceed along exactly the same lines. See below §4.2 for the effects of a similar Coda-Condition on Axininca Campa phonology and morphology.

coda-containing, so the ultimate decision is passed down the hierarchy. Since classical prefixation violates EDGEMOST not at all, it is manifestly more harmonic than any competitor.

The constraint NOCODA can force the affix even further in; consider words beginning with consonant clusters:

(12) CC-initial words /um+gradwet/

Candidates	NOCODA	EDGEMOST
.UM.grad.wet.	*** !	∅
.gUM.rad.wet.	*** !	g
<sup>u</sup> grU.Mad.wet.	**	gr
.grad.wUMet.	**	gradw !

(We show only one candidate with excessively deep infixation; the others work the same way.)

It is evident from the tableau (12) that the entire initial cluster must be skipped; placing *um* amid consonants offers no improvement, codaically speaking, over placing it before the entire cluster. Putting the affix even further inside, somewhere past the first vowel, also achieves no improvement in the coda situation; at best it maintains the level of violation. The affix therefore sits right after the first cluster in the optimal form, this being the leftmost site where no new closed-syllable violations are introduced. The result, therefore, doesn't rely on any assumption that the initial C-sequence is an actual constituent, an "Onset". We take up this matter below in §7, where we investigate this range of phenomena in greater depth.

The constraint hierarchy NOCODA  $\gg$  EDGEMOST(L,um) entails that the affix will be situated right after the initial consonant sequence of the word, and, when there is no consonant sequence, right at the beginning of the word. The argument for this has been heuristic, though presumably convincing. To establish the result securely, one must show that it holds not of a few selected inputs, but of every possible input string. This is not difficult (Prince and Smolensky 1993). It is worth keeping in mind, however, that the effects of a grammar range over large, typically infinite, sets. The optimal output is selected from the whole candidate set arising from a given input; and to say that a linguistic pattern holds of a language is to make an assertion about the set of all outputs of the grammar. Consequently, it requires a theorem of sorts to establish that a certain candidate is optimal, just as it does to establish that a certain linguistic pattern emerges from the grammar.<sup>11</sup> We shall often proceed informally in our demonstrations, but we hope that it will always be clear what few additional steps need be taken to prove the results we claim.

Optimality Theory asserts that permuting the ranking of constraints in a grammar gives another possible linguistic system; indeed, re-ranking ought to generate every possible linguistic system, once we know what set of substantive constraints UG makes available. If we reverse the ranking here, so that EDGEMOST  $\gg$  NOCODA, the syllabic constraint will be rendered irrelevant

<sup>11</sup>This is not an entirely new burden that Optimality Theory alone lays on the grammarian. Familiar species of grammatical description show comparable or greater complexities, and failure to check out their consequences thoroughly invites theoretical disaster, public embarrassment, and unintended enrichment of other people's careers.

by the morphological positioning principle. Dominance of EDGEMOST yields the classic prefix, uniformly situated at the edge of its domain.<sup>12</sup> For this case, then, re-ranking is entirely sensible.

A central property of the Tagalog example is that a prosodic constraint (like NOCODA) is ranked above a morphological one (like EDGEMOST). This ranking produces a pattern in which a morphological phenomenon is determined in part by phonological conditions. This constraint configuration lies at the heart of Prosodic Morphology, and will be extensively studied as we proceed.

## 2.2 Syllable Theory

Prosodic Morphology rests on prosodic phonology. Reduplication is sensitive in Axininca Campa, as elsewhere, to a variety of conditions on syllabic well-formedness. It is useful, therefore, to lay out key aspects of the syllable theory we will be drawing on, which comes from Prince and Smolensky (1991b, 1993:§6).

Syllable structure is generated under Optimality Theory in the same way as any other grammatical property. The function Gen produces a candidate set of syllabic parses for each unsyllabified input. The output of Gen accords with the most fundamental structural principles, those that define what structures are to be contemplated as possible, enumerating the vocabulary of categories and ensuring, for example, that  $\sigma$  dominates  $\mu$  and not vice versa. Under these broad conditions, there will be a large variety of candidate analyses for any given input; Universal Grammar gives a set of well-formedness conditions, which, ranked into a grammar, will select the optimal candidate from among the set of possibilities.<sup>13</sup>

Consider a simple input with the shape /CVCV/. The most obvious question to be decided is the affiliation of the medial C. If the language allows syllables CVC, then we have the following salient candidates to reckon with:

### (13) Some Candidate Syllabifications of /CVCV/

- a. .CVC.V.
- b. .CV.CV.

The first syllable of (13a) is closed, violating the constraint NOCODA, which requests that syllables end on vowels. The second syllable of (13a) violates the well-known constraint that syllables should begin with consonants, which we will call ONSET (Ito 1986, 1989).<sup>14</sup> Since the doubly-open form (13b) meets both constraints, it will clearly be selected as optimal, regardless of any assumptions about constraint ranking. Any grammar that has either constraint in it — and

---

<sup>12</sup>The relation between the two constraints is as special case to general case, which entails the swamping effect when the general case dominates, by ‘Pāṇini’s Theorem’ (Prince and Smolensky 1993:§7). We return to this property below in §5.

<sup>13</sup>This general approach to syllabification has been explored under various guises in the literature, including Anderson (1982), Bosch and Wiltshire (to appear), Broselow (1982, 1991), Cairns and Feinstein (1982), Cairns (1988), Clements (1990), Goldsmith (1990), Harris (1983), Itô (1986, 1989), Itô and Mester (1991), Kaye and Lowenstamm (1981, 1984), Lamontagne (1992), LaPointe and Feinstein (1982), Noske (1982), Selkirk (1981), Wiltshire (1992), and Zec (1988, 1992), and others. For a different view of how syllabification proceeds, see Steriade (1982), Levin (1985).

<sup>14</sup>Prince and Smolensky (1991b, 1992, 1993) refer to these as –COD and ONS respectively.

all grammars have both — assigns a unique, purely open syllabification to input /CVCV/. No special rule of Onset Formation is called for; the constraint structure is sufficiently strong to make the decision on its own, as long as it is allowed to contemplate a rich set of possibilities.

Many other candidates are consistent with the basic conditions on the constituent structure of syllables. We list a couple more here:

(14) More Candidate Analyses of /CVCV/

- a. .C.V.C.V.
- b. ⟨CVCV⟩

The first candidate (14a) is tetrasyllabic by virtue of putting every segment in its own syllable; it has two onsetless syllables, violating ONSET, and also syllabifies C, often disallowed. The second candidate (14b) goes to the other extreme: it has no syllable structure whatsoever. (We indicate unparsed elements by placing them between angled brackets.) Lacking structure, it cannot violate any constraints sensitive to the *presence* of structure, like ONSET and NOCODA. In terms of structural constraints, the unparsed output [⟨CVCV⟩] is exactly as good as the correct doubly-open parse — it's perfect.

Failure to incorporate segments into syllable structure violates the *Prosodic Licensing* of Itô (1986, 1989). Taking up this idea, Optimality Theory recognizes a family of constraints under the name of PARSE, which require that a given element be dominated by an appropriate node in the prosodic tree, 'parsed'. PARSE-*seg* demands that the segments belong to syllabic or moraic structure; PARSE- $\mu$  demands that a mora  $\mu$  is dominated by  $\sigma$ , the syllable node; PARSE- $\sigma$  that syllables belong to feet (or PrWd (Itô and Mester 1992)); and so on.

Every grammar contains these constraints; their relation to other constraints determines the conditions under which elements are left free. Let's confine our attention to PARSE-*seg*, which we will refer to simply as PARSE. There will necessarily be a conflict between PARSE and any constraint that militates against certain structures. NOCODA is a good example; it aims to prohibit closed syllables, yet an input like /CVC/, for example, has among its possible analyses the straightforward, all-inclusive parse [.CVC.]. How can we have closed syllables at all when there is a well-founded universal constraint against them? Suppose PARSE dominates NOCODA. Then the following comparison is relevant:

(15) Dominance of PARSE in a Language Admitting Closed Syllables

/CVC/	PARSE	NOCODA
☞ .CVC.		*
.CV.⟨C⟩	* !	
⟨CVC⟩	*** !	

Here violation of dominant PARSE is fatal, even though it leads to the avoidance of syllable-final C demanded by NOCODA. Languages which admit closed syllables do so in violation of NOCODA, which must be forced by a higher-ranking constraint, in this case PARSE.

Ranking the constraints in the opposite order produces a different language, one in which closed syllables are in fact banned.

(16) Dominance of NOCODA, Prohibiting Closed Syllables

/CVC/	NOCODA	PARSE
.CVC.	* !	
☞ .CV.<C>		*
<CVC>		*** !

Here the closed-syllable parse is eliminated by dominant NOCODA. Forms that do meet NOCODA are subject to comparative evaluation by PARSE. Harmonic Ordering entails that optimal forms will display minimal violation, as noted above. Consequently, for input /CVC/ the exclusion of just a single C from syllable structure is the optimal outcome.<sup>15</sup> In accordance with the standard theory of the matter (McCarthy 1979a, Steriade 1982, Itô 1986, 1989), unparsed elements are erased upon exit from the level.

Prosodic analysis can involve a notably more aggressive interpretation of the input as well. Selkirk (1981) and Itô (1986, 1989) demonstrate that if the syllable parse is allowed to posit segmentally unmotivated structure, the location of certain so-called epenthetic elements follows from independently required principles of syllabification. The full candidate set must therefore freely include parses with empty positions — daughterless nonterminal nodes — at any level of the prosodic hierarchy. Such defective positions are, of course, a liability. Their presence therefore represents a violation of fundamental constraint which Prince and Smolensky call FILL. The idea behind the name is that all nodes should dominate their expected daughters; that is, be appropriately filled.<sup>16</sup> Writing □ to indicate an empty syllabic position, we have analyses like the following to evaluate:

(17) Analyses of /CVC/ with Empty Positions

- a. .CV.C□.
- b. .CV□.C□.
- c. .CV.C□□.
- d. .CV.C□.□□.

<sup>15</sup>This is not a *proof* that the language in its entirety prohibits closed syllables; only that a closed-syllable parse cannot be given to a certain single input /CVC/, which is (as it happens) particularly likely to invite such a parse. For the proof, see Prince and Smolensky 1993:§6.

<sup>16</sup>FILL, like PARSE, must ultimately be parametrized by the kind of structural entity it pertains to (Prince and Smolensky 1991b, 1993:§6). But Axininca requires no such subtlety, and we will overlook it (v. §4.3 for further discussion). FILL belongs to class of constraints which militate against the presence of structure \*STRUC, ensuring minimal structural development in response to any dominant PARSE considerations. In a fully general account, this would include filled as well as empty or partly empty nodes, not to mention autosegmental links, grid positions, and so on. The same constraint family is active in syntax and even semantics. For example, Chomsky's suggestion that X' nodes appear only when accompanied by a sister falls naturally under \*STRUC (Chomsky 1986:4).

(For purposes of the present discussion, let the candidate set never contain tautosyllabic CC or VV; this eliminates any ambiguity in the interpretation of the typographic symbol □.)

Measuring these for the moment only against the fully parsed [.CVC.], we see that if FILL dominates NOCODA, all candidates containing empty positions will be banned.

(18) Dominance of FILL

/CVC/	FILL	NOCODA
☞ .CVC.		*
.CV□.C□.	* ! *	*
.CV.C□□.	* ! *	*
.CV.C□.□□.	* ! **	
.CV.C□.	* !	

Here, even one violation of FILL is fatal. The ground-hugging parse [.CVC.] is better than any of the more inventive interpretations of the input string which posit empty structure.

With the opposite ranking, a different picture emerges. Now satisfaction of NOCODA is paramount, and FILL gives way to achieve it.

(19) Dominance of NOCODA

/CVC/	NOCODA	FILL
.CVC.	* !	
.CV□.C□.	* !	**
.CV.C□□.	* !	**
.CV.C□.□□.		** ! *
☞ .CV.C□.		*

In this mini-grammar, an input /CVC/ is analyzed as consisting of two open syllables. Only the last two candidates in the tableau survive the constraint NOCODA; they are therefore crucially compared on FILL. With a single empty position, the disyllabic candidate is superior to the trisyllabic, and indeed to all the other possibilities (tetrasyllabic, pentasyllabic, and so on) that are not listed. Disyllabicity is the least divergence from simple segment-driven parsing that suffices to ensure that all syllables are open. As with all constraints, violation of FILL must be minimal. This entails the “quite general principle according to which, all else being equal, the number of dummy positions in the underlying syllabification is to be minimized” (Selkirk 1981:215).

The interaction of FILL and ONSET is similar in character. When FILL is dominant, empty positions are effectively banned, so an input like /V/ cannot be syllabified with an empty onset as [□V]. With ONSET dominant, by contrast, onset-containing [□V] is superior to FILL-obscuring [.V], even though an empty position is present. This last state of affairs is shown in the following tableau:

(20) ONSET Dominating FILL

/V/	ONSET	FILL
☞ □V.		*
.V.	* !	

The two-constraint grammar ONSET  $\gg$  FILL forces onsets at the expense of FILL.

PARSE and FILL are representatives of a family of *faithfulness* constraints, which demand a tight relation between input and output forms.<sup>17</sup> For purposes of expositional clarity, we have artificially narrowed the set of nonfaithful candidates to suit the individual constraint under discussion. First, dealing with PARSE, we looked only at nonfaithful candidates with unparsed material — PARSE violators. Then, focusing on FILL, we chose to examine only those with empty positions — FILL violators. But if Gen allows unparsed segments and empty nodes, then the candidate set for *any* input must contain both kinds of deviation from faithfulness. The full typology of basic syllable-parsing effects emerges only when we include all manner of conceivable parses in the candidate set. To determine the optimal parse in any given language, we must consider the interaction of both PARSE and FILL with the basic structural constraints on syllable form, ONSET and NOCODA. Here we will describe the main lines of the interaction, following on the full exploration in Prince and Smolensky (1993:§6).

First, note that ONSET and NOCODA cannot interact directly; no candidate meets one by virtue of violating the other, for essentially geometrical reasons. There is simply no way that lack of an onset (\*ONSET) can lead to there being more open syllables in a form. Nor can possession of a coda (\*NOCODA) lead to an increase in the number of onsets about. Thus we can attend to two distinct trios of constraints, in which the faithfulness pair PARSE and FILL confronts either of the two structural constraints.

A key insight is that in any ranking of PARSE, FILL, and ONSET (or NOCODA, for that matter), it is the lowest-ranked constraint that determines the disposition of the problematic cases. This is because the crucial candidates will satisfy two of the three constraints while violating only one of them. To see this, suppose ONSET is lowest, ranked below both PARSE and FILL. The important candidate to examine is /V/:

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<sup>17</sup>For extensions of the family beyond simple PARSE and FILL, to deal with other phonological relations (e.g. linkage) and with input that is already parsed, see Hung (1992) and Samek-Lodovici (1992, 1993).

## (21) ONSET at the Bottom — Onsetless Syllables Allowed

/V/	FILL	PARSE	ONSET
 .V.			*
⟨V⟩		* !	
.□V.	* !		

(The dotted line indicates that relative ranking of PARSE and FILL is not significant.)

The faithful parse [.V.] violates ONSET, but challenges neither PARSE nor FILL. The asyllabic candidate [⟨V⟩] violates only PARSE, meeting all structural conditions vacuously by virtue of having no structure at all. The epenthetic candidate [.□V.] violates only FILL; the input is fully parsed and the resulting syllable is unimpeachable. With PARSE and FILL dominating ONSET, all the demands of faithfulness must be met, and syllable structure well-formedness is sacrificed. The language admits onsetless syllables.<sup>18</sup>

It might be thought that this language could be equally well defined by simply excluding ONSET from the grammar entirely, domination be damned. Nothing could be further from the truth. The constraint system says, correctly: onsetless syllables are optimal *only under segmental compulsion*. An input /V/ can only be faithfully parsed into an onsetless syllable, given the segmental material that it contains. For an input /CVCV/, however, the presence of ONSET in the grammar forces [.CV.CV.], in this language as in all others (Prince and Smolensky 1991a, 1991b, 1993:§6).

Suppose now that FILL is lowest of the three. It becomes necessary to avoid violating the dominant constraints PARSE and ONSET; to avoid onsetless syllables while omitting no elements from prosodic structure. The nonparse [⟨V⟩] satisfies ONSET vacuously, but at the cost of nonparsing. In the low-FILL system, there is a better way to satisfy syllabic well-formedness: via empty structure.

## (22) FILL at the Bottom, No Onsetless Syllables

/V/	ONSET	PARSE	FILL
.V.	* !		
⟨V⟩		* !	
 .□V.			*

Lowest-ranked FILL means epenthesis, to use the traditional vocabulary of the field. The structural constraints that dominate FILL — here, only ONSET — determine the conditions under which epenthetic material appears. A low-FILL language bans onsetless syllables, as may be proved by considering the fate of all possible inputs. Potential challenges to dominant ONSET,

<sup>18</sup>This is a proof. To allow is to show at least one instance in the output; to prohibit is to quantify universally over the whole set of outputs.

such as are posed by V-initial input and by VV hiatus within underlying forms, always lead to the optimality of epenthetic candidates.

In the remaining case, PARSE has lowest rank. Problematic input will be dealt with by nonparsing.

(23) PARSE at the Bottom, No Onsetless Syllables

/V/	ONSET	FILL	PARSE
.V.	* !		
☞ ⟨V⟩			*
.□V.		* !	

In a language with the low-PARSE ranking, it can be shown that onsetless syllables are strictly prohibited; the onset requirement is enforced, ultimately, by phonetic deletion.

The three distinct rankings thus yield a universal typology of onset-related interactions. Whenever ONSET dominates at least one of the faithfulness constraints, every syllable in the language must have an onset, no matter what the input string is. (How the onset requirement is enforced depends upon which of the faithfulness constraints is lowest-ranked.) When both faithfulness constraints rank above ONSET, then syllable onsets are required only when sufficient segmental material is available in the input; that is, when the input contains the substring CV. Significantly, the theory provides no way to *ban* onsets from the syllabic repertory of a language; nor is there a way to discriminate against them in any context, favoring a parse ~C.V~.

A similar typology of coda-connected phenomena emerges from the interactions of NOCODA, FILL, and PARSE. Codas are banned entirely when NOCODA dominates at least one of the faithfulness constraints: a nonfaithful coda-free parse, either epenthetic or deleting, must then be optimal. Codas are admitted in languages where both faithfulness constraints rank above NOCODA: in this case, codas appear in the parse only when forced by faithfulness, as in dealing with an input like /CVC/. Here too there is a significant typological result: it is impossible to configure a grammar so that codas are present in every syllable.

The very basic PARSE/FILL and ONSET/NOCODA theory thus generates the Jakobson (1962:256) typology of fundamental syllable structure patterns: onsets may be required, or they may be ‘optional’; codas may be forbidden, or they may be allowed. The theory goes beyond an inventory-oriented conception, however. The paradigm of syllable types follows from their syntagmatic distribution, from what happens in the parsing of individual strings. This is characteristic of Optimality Theory: if UG supplies the constraints out of which individual grammars are directly constructed, then such constraints — which may often be identified with apothegms of markedness — will not be inert summaries of tendential repertory patterns, but instead the very principles responsible for the assignment of grammatical structure.

The basic theory laid out here deals with the most fundamental aspects of syllable structure, which are often accompanied by further elaborations: complex intrasyllabic sequences, sonority effects, linking effects on coda consonants, and so on. These have been the object of considerable linguistic study — Clements (1990) and Kenstowicz (1993:Ch. 6) review much of literature on the subject. Prince and Smolensky (1993), Kirchner (1992b), Rosenthal (in prep.),

and Sherer (in prep.) extend the present theory to approach some of these phenomena. Many languages, Axininca Campa among them, fall pretty much within the purview of the basic theory, and we may proceed to build the analysis of Axininca prosody and prosodic morphology upon it.

### 2.3 Gen and Linguistic Structural Assumptions

Because Optimality Theory works by assessing candidate outputs, it is essential to establish what a candidate set actually consists of: to define the function Gen. In principle, UG fixes Gen for all languages, posing a heavy burden for the theorist who wishes to deal only in final certainties. In practice, of course, it is appropriate to make provisional commitments on technical matters, and even to exclude certain complexities, so long as there is reasonable confidence that the fundamental distinctions made are well-founded and likely to survive the inevitable reshaping and generalization that thought is heir to. We therefore choose our assumptions with an eye to empirical plausibility, but also so that minimal technical development is required to yield the results we wish to obtain.<sup>19</sup>

Three principles underlie the theory of Gen assumed here, the first two taken from Prince and Smolensky (1993):

1. **Freedom of Analysis.** Any amount of structure may be posited.
2. **Containment.** No element may be literally removed from the input form. The input is thus contained in every candidate form.
3. **Consistency of Exponence.** No changes in the exponence of a phonologically-specified morpheme are permitted.

True Freedom of Analysis means that Gen may supply candidates with syllabic, moraic, or other prosodic structure, with association lines, and with additional segmental material, ranging from empty root nodes through fully specified vowels or consonants. The countervailing force of Containment limits this freedom in one specific way: the input (the underlying representation) must be present in any licit candidate.

Freedom of Analysis is an essential premise of the theory. Because of it, the basic principles of representational form supply a range of candidates so inclusive that no specific rules or repair strategies need be posited. There is, for example, no rule ‘add mora’, because syllabification already, as it were, adds moras. The constraint hierarchy of a given language exerts control over the teeming space of possibilities, as we have seen in the discussion of the basic syllable structure theory.

The Containment property has been assumed in all Optimality Theoretic analyses to date. (It is related to monotonicity in Categorical Phonology (Wheeler 1981, Bach and Wheeler 1981) and Declarative Phonology (Scobbie 1992).) As usual, it is interesting and useful to conceive of

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<sup>19</sup>*Vulgo*: Because constraints in Optimality Theory assess candidates provided by Gen, we need to say what Gen is. Gen is presumably universal, so its properties cannot be known completely until we understand every phonological alternation in every language — currently a practical impossibility. This may initially seem like a problem, but actually a lot *can* be determined about Gen, and what isn’t known is unlikely to affect solid results. A particularly safe approach, which we follow here, is to attribute to Gen only those broadly-based properties that phonology obviously requires. It is also a good idea, and one that we also follow, to avoid technical chicanery in Gen. Thus, we do not derive crucial results from otherwise unmotivated properties of Gen.

contrary positions. Other assumptions may lead to variant paths of development and a welcome diversity of results.

Consistency of Exponence means that the phonological specifications of a morpheme (segments, moras, or whatever) cannot be affected by Gen. In particular, epenthetic segments posited by Gen will have no morphological affiliation, even if they are bounded by morphemes or wholly contained within a morpheme. Similarly, underparsing will not change the make-up of a morpheme, though it will surely change how that morpheme is realized phonetically. Thus, any given morpheme's phonological exponents must be identical in underlying and surface form, unless the morpheme has no phonological specifications at all (as is the case with the reduplicative affix RED, discussed in §5.2). Something similar to Consistency of Exponence was first mooted by Pyle (1972:522), who noted that morphological boundary theory implausibly requires that epenthetic segments be assigned an arbitrary morphological affiliation.

We must also make various linguistic assumptions, in order to specify the kinds of structures that Gen can posit, to provide a basis for formulating the phonological constraints, and to supply an interpretation for output representations. These assumptions are, of course, shared with many other theories of linguistic form — they are the basis of most of contemporary phonological theory. Some are discussed later, as they become important to the analysis; the Prosodic Hierarchy and foot typology, for example, are treated in §4.3. Others, though, are of such pervasive significance that we lay them out here:<sup>20</sup>

- [1] **Moraic Representation.** The syllable node ( $\sigma$ ) may dominate one or two mora nodes ( $\mu$ ). Each mora dominates at most one segmental root. Onset consonants are daughters of  $\sigma$ :



(See van der Hulst 1984, Hyman 1985, McCarthy and Prince 1986, 1988, Hayes 1989, Zec 1988, Itô 1989, Dunlap 1991, NíChiosáin 1991, Perlmutter 1992a, among others.)

- [2] **Long/Short Distinction.** A vowel root-node associated with a single mora is short; a vowel root-node associated with two moras is long. Vowels, long or short, come with moraic structure attached in the lexicon (as in Hayes 1989; cf. McCarthy and Prince 1988, Inkelas and Cho 1992).
- [3] **Default Interpretation.** At the end of a level, there is an interpretive component — a “phonetics” of the level — that fills in default values. Empty root-nodes are provided with featural structure; empty moras with root-node structure; and so on. Unprosodified material is “stray-erased” — that is, it receives no interpretation.<sup>21</sup> (On empty structure, see Selkirk 1981:215, Archangeli 1984:36, etc.; on stray erasure, McCarthy 1979a, Steriade 1982, Itô 1986).
- [4] **Empty mora.** Empty moras are interpreted as vocalic. An empty second mora is interpreted as sharing the content of the first mora (cf. Prince 1975).

<sup>20</sup>Different assumptions than these, especially 1. and 2., are explored at length by Rosenthal (in prep.) and Sherer (in prep.).

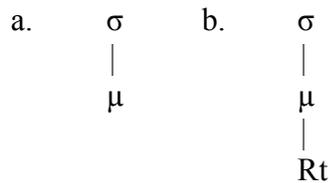
<sup>21</sup>The proposal that unsyllabified segments persist, made for Bella Coola (Bagemihl 1991) and Spokane Salish (Bates and Carlson 1992), is obviously problematic in this regard.

Points [1] and [2] are nothing more than the familiar moraic theory of syllable structure. Point [2] incorporates one particular clarification, important in the current context: underlying vowel length distinctions are represented by lexical mora specifications, so they must be present (though not necessarily realized) in all candidate forms, in conformity with Containment. Points [3] and [4] pertain to the interpretation of output forms, again making familiar assumptions about default specification and stray erasure. Point [4] adds a clarification: empty moras receive vocalic construal, either as a default vowel or as a continuation of a vowel in the same syllable.

This way of interpreting empty moras permits us to maintain a simple and consistent model of the structures underlying epenthesis and vowel lengthening phenomena. We observed above (fn. 16) that FILL belongs to a class of constraints whose most general member is \*STRUC: avoid structure. No matter where \*STRUC lies in a grammatical hierarchy, it will force structural minimization unless other, dominant constraints compel structural elaboration.

In particular, \*STRUC will determine the form of the structures that underlie phenomena like epenthesis and lengthening. For vocalic epenthesis, there will be choices like these:

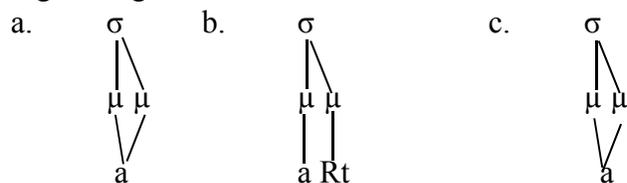
(24) Vocalic Epenthesis (Rt = feature-geometric root-node)



In a situation that compels epenthesis, and we will see many, Gen supplies highly harmonic candidates containing structures like (24a) and (24b), both of which will lead to an interpretation with an epenthetic vowel. But \*STRUC asserts that the form in (24a) is superior. The linked root-node *Rt* in (24a) is unnecessary, since the syllable is structurally sound without it and will satisfy any constraint that forces the presence of an empty syllable. Thus, the less elaborated structure is the designated output form.

By the same reasoning, in a situation that compels vocalic lengthening, the output (25a) will be selected by \*STRUC over (25b, c), which posit additional structure that is unnecessary to fulfill any heaviness requirement that might be imposed on this syllable.<sup>22</sup>

(25) Vocalic Lengthening



The linked root-node in (25b) and the additional link in (25c) are equally supererogatory. Following point [4] above, the interpretation of the empty mora in (25a) is as a continuation of the preceding vowel (since a true default vowel is universally impossible in this context).

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<sup>22</sup>Other assumptions about linguistic structure, such as the two-root theory of length (Selkirk 1988), will naturally require a different approach to vocalic lengthening in output representations.

With consonantal epenthesis phenomena the situation is different. Because we do not reify the onset as a constituent, the only way to satisfy the constraint ONSET is by interpolation of a consonantal root-node among the segments of the underlying form. The phonological representation of a C-epenthetic form will therefore be  $[Rt \dots]_{\sigma}$ . Even in this case, \*STRUC rejects candidates that posit additional structure, unnecessary to satisfy ONSET, such as place-nodes, laryngeal-nodes, and so on.

In Axininca Campa specifically, the empty consonantal root-node is realized as [t], and empty moras are interpreted as [a] or, when preceded by a tautosyllabic vowel, as a continuation of it. For mnemonic purposes, and to limit the profusion of notational elements in cited forms, we will use the symbol  $\mathbb{T}$  to transcribe the empty C-root and the symbol  $\mathbb{A}$  to transcribe the empty mora.

### 3. The Stratal Organization of Axininca Campa Morphology

All reduplication takes place within the broader system of morphological and phonological regularities that define a language. The simple, abstract templatic conditions of Prosodic Morphology rest on the groundwork of universal and particular grammar. To assert that a reduplicative affix is a *heavy syllable*, for example, or that it is a *suffix*, will have significant consequences, precisely because such notions are independently endowed with meaning. Reduplicative form in Axininca Campa is thoroughly responsive to the general morphology and phonology of the language; we therefore approach reduplication through a characterization of the relevant grammar: morphological structure first (§3) and then the phonology that arises from it (§4).

Axininca Campa morphology is both prefixational and suffixational. Prefixes in nouns and verbs principally mark *Spec* of DP and IP — possessor and subject — as in the following examples:

#### (1) Spec Prefixes

- a. no-*mapi-ni*            ‘my rock’
- b. no-*saik-i*             ‘I will sit’

There are a few other prefixes like *N-* (a nasal archisegment) ‘future’ and *o-* ‘causative’.

Verbal suffixes mark various distinctions of tense, mood, and internal argument. The reduplicative suffix is one such, marking repeated action. There are very few nominal suffixes and they are of limited phonological interest.

Although the morphological functions of prefixation and suffixation partly overlap, their phonological properties are quite different, both in character and in degree of generality. In terms of a standard Lexical Phonology of the grammar, it is plausible to assume that there are distinct Prefix-level and Suffix-level constraint systems, with Prefix level preceding and therefore feeding Suffix level. (It is also possible to construe the prefix-related alternations as mere allomorphy.) In addition, it is clear that there is a distinct Word level, which is principally the domain of stress and related phenomena, taken up in some detail in the Appendix. Thus, the overall architecture of the grammar would be as follows:

#### (2) Lexical-Phonological Organization



Each level constitutes a separate mini-phonology, just as in ordinary rule-based Lexical Phonology (e.g., Kiparsky 1982, Mohanan 1982, Borowsky 1986) or in the level-based rule + constraint system of Goldsmith (1990, 1991).<sup>23</sup> The constraint hierarchies at each level will overlap only in part, and will in fact specify somewhat different constraint rankings. Each

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<sup>23</sup>Goldsmith also makes a very interesting proposal about the *interface* between levels, which is echoed in our claim (in the Appendix) that there is some reduction in structure, akin to Bracket Erasure, between Suffix Level and Word Level.

level selects the candidate form that best satisfies its parochial constraint hierarchy; the winning candidate is fully interpreted by filling in empty moras or incomplete root-nodes and by erasing unparsed material. This interpreted representation then becomes the input, the underlying representation, for the next level in the derivation.

Challenges to syllabic well-formedness posed by morphemic combination are met quite differently at Prefix-Root and Stem-Suffix junctures. In prefixal allomorphy, syllabically ill-formed V+V or C+C sequences are resolved by loss of material from the prefix, never by epenthesis. Construed as phonology, this means violation of PARSE, but not FILL, as the following examples illustrate:

### (3) Violation of PARSE in Prefixal Allomorphy

a. /ir-saik-i/	i⟨r⟩saiki	[isaiki]	‘will sit’
b. /no-ana-ni/	n⟨o⟩anani	[nanani]	‘my black dye’

Consequently, FILL  $\gg$  PARSE at the Prefix Level, rendering omission of material from syllabic structure — PARSE-violation — the least offensive choice. (Root-final consonants, despite being unsyllabifiable, would have to survive a Prefix level unscathed, perhaps by virtue of final extrametricality.)

At the Suffix Level, by contrast, PARSE is scrupulously observed; there is no loss at all of morphemic material. Syllabically problematic inputs V+V and C+C are resolved by positing empty (epenthetic) structure, both vocalic and consonantal, in violation of FILL, as will become abundantly clear below. Consequently PARSE  $\gg$  FILL here, favoring candidates with epenthesis over those with unparsed elements. The upshot is that, assuming prefix-specific phonology (rather than prefixal allomorphy), the Prefix Level must be distinct from the Suffix Level by virtue of a fundamental difference in constraint ranking, corresponding to the notion that separate levels constitute separate mini-phonologies.

Further evidence shows prefixal material must be visible to conditions on suffixation. This implies at a minimum that prefixal morphology and phonology can take place **no later than** suffixal morphology. Suffixes, for example, impose on their bases a bimoraicity requirement which can be satisfied by the prefix+root combination (§4.3 below). This requirement is evidenced by the treatment of the root /na/ in the following examples, which include the suffix *-piro* ‘verity’:

### (4) Bimoraicity of Base of Suffixation

<i>Stem</i>	<i>Suffixed form</i>	
a. /na/	na <sup>TA</sup> -piro <sup>~</sup>	‘truly carry on shoulder ...’
b. /no-na/	no-na-piro <sup>~</sup>	‘I truly carry on shoulder ...’

Unprefixed /na/ is phonologically augmented to bimoraicity; but the prefixed form shows no augmentation, because *no-na* together constitute two moras. This shows that the suffix sees the prefix-root combination and not just the root.

Similarly, prefixes are carried along in reduplication just in order to satisfy another requirement, distinct from bimoraicity, on the *disyllabicity* of the reduplicated string (§§5.2–5.4 below):

## (5) Disyllabicity of Reduplicative Copy

<i>Root</i>	<i>Stem</i>	<i>Stem+RED</i>	
a. /naa/	/no-naa/	no-naa- <u>nonaa</u> -~	‘I chew more and more ...’
b. /asi/	/n-asi/	n-asi- <u>nasi</u> -~	‘I cover more and more ...’

The suffix RED, then, like other suffixes, sees the whole prefix-root collocation.

Reduplication also records the results of Prefix-level phonology in what has come to be called “overapplication”. For example, the causative prefix *o-* triggers lenition of initial *p* in both base and copy in examples like this:

## (6) Carry-over of Prefix-induced Allomorphy

<i>Root</i>	<i>Complex Form</i>	<i>Reduplication</i>
/piɪŋka/	/no-o-piɪŋka-RED/ ‘1st+caus.+submerge+redup.’	no- <u>wiɪŋka</u> -wiɪŋka

This shows that reduplication presupposes the outcome of prefix-root interaction.

The conclusion is that the prefix + root sequence lies within the domain of the suffix, visible in its entirety to conditions on suffixal morphology. Below, it will emerge that reduplication, though suffixal, can distinguish prefix from root *inside* the prefix-root complex (§5.3). Thus, we must have the following constituent-structural analysis of morphology, to which phonology is sensitive:

## (7) Morphological Constituency

Prefix + Root = Stem  
Stem + Suffix = Stem

We will not offer an analysis of the Prefix level here, since it is fraught with idiosyncrasies that are not particularly amenable to phonological treatment.<sup>24</sup> It may well be that there is no Prefix level in the phonology, and that all of its alternations are consequences of allomorph selection, which can just as well be done in parallel with the Suffix level phonology and morphology.<sup>25</sup> This is a point of general theory, upon which Axininca Campa sheds no particular light, and it is of peripheral relevance to the main concerns here.

Neither will we be discussing the morphologically restricted rules affecting various suffixes. We have not yet attempted to integrate our results with the phonology of palatalization in Axininca Campa, though we see no obvious impediments. Subject to these limitations, though, we will present a thorough analysis of the prosodic phonology and morphology of the language.

<sup>24</sup>For example, the third person masculine prefix has a unique pattern of free variation among *ir-ana-ni* ~ *r-ana-ni* ~ *h-ana-ni* ‘his black dye’. Similarly, root-initial *p* and *k* spirantize after a prefixal vowel in alienably possessed nouns (*no-woritati* ‘my small hen’ from /porita/) and in causative verbs (*o-wiɪŋkaanc<sup>hi</sup>* ‘to dunk’ from /piɪŋk/), but not in inalienably possessed nouns (*no-pori* ‘my thigh’) or non-causative verbs (*no-piɪŋkaki* ‘I will dunk’).

<sup>25</sup>See Mester (to appear) for proposals about allomorph selection within Optimality Theory.



## 4. The Prosodic Phonology of Axininca Campa

Axininca Campa is rich in epenthesis and augmentation. Extra structure is justified by the familiar kind of narrow syllable-structure canons as well as by less well studied constraints on the alignment of morphemes with prosodic structure. Because certain optimal forms contain structure not present underlyingly, FILL is violated and must be subordinated in the constraint hierarchy. Those constraints which dominate FILL determine the extent and character of such violations. Here we examine the role of coda requirements (§4.1), the onset requirement (§4.2), and three important aspects of the morphology-to-prosody mapping (§4.2, §4.3). This will yield a complete grammar of FILL-violation in the language.

### 4.1 Basic Syllable Structure I: CODA-COND

Epenthesis in Axininca Campa is motivated in part by well-formedness conditions on syllable structure, as previous studies have established (Levin 1985:330-331, Itô 1986:155-161, Itô 1989:236-239, Spring 1990a:45-53, Black 1991a:186-187). Optimality Theory allows us to embody this insight directly in the formulation of the grammar.

The overall structure of the Axininca Campa syllable is CV(V)(N). The onset is obligatory, except that the initial syllable of a Prosodic Word can be onsetless. (The vocalic nucleus is obligatory as well.) The vowels /i e a o/ can be long or short and there are also two diphthongs, *ai* and *oi*. The only permissible coda consonant is a nasal homorganic to a following stop or affricate. Nasal geminates and nasal-continuant clusters are prohibited, as are word-final nasals.

The limitations on possible consonant clusters influence the patterns of epenthesis. Several distinct constraints, each independently motivated, are called for:<sup>26</sup>

- a restriction on coda consonants, limiting them to nasals that share Place with a following consonant (Itô 1986, 1989);
- a restriction on Place linking, prohibiting it between a nasal and a continuant (Padgett 1991);
- an outright prohibition on geminates, including nasal geminates.

Full exploration of these conditions, all unviolated, is peripheral to the main concern here, so we will simply summarize the needed result in a single covering constraint, a Coda-Condition (to use Itô's term) that follows from the three more basic constraints just listed:

#### (1) CODA-COND

A coda consonant is a nasal homorganic to following stop or affricate.

CODA-COND plays a central role in deriving a basic junctural generalization of Axininca Campa: C+C clusters derived by suffixation can *never* be faithfully syllabified. When suffixation puts C against C, the first consonant is supported by an epenthetic vowel (Payne 1981:108f.). The examples in (2) below show epenthesis, spelled **A**, into clusters derived by suffixing *-wai* 'continuative' to various C-final roots. The symbol ~ marks the critical morpheme junctures:

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<sup>26</sup>See Zec (1992) for a discussion of such constraints within Optimality Theory.

## (2) Fate of C+C

/no-N- <i>č<sup>h</sup>ik</i> ~wai-i/	noñč <sup>h</sup> i <u>k</u> ΔwaiTi	‘I will continue to cut’
/no-N- <i>tasonk</i> ~wai-i/	nontason <u>k</u> ΔwaiTi	‘I will continue to fan’
/no-N- <i>aacik</i> ~wai-i/	naacik <u>k</u> ΔwaiTi	‘I will continue to stop’

The *k+w* clusters in the underlying representations cannot be faithfully syllabified without violating CODA-COND. Forms with epenthetic Δ face no such problem.

The epenthetic elements are phonetically realized as [t] and [a]. In accord with the assumptions laid out in §2.3, vocalic epenthesis is the phonetic interpretation of an empty mora in the optimal syllabic parse. Consonantal epenthesis involves the presence of an empty segmental root node, devoid of featural or nodal structure, daughter to σ. Orthographically, we will indicate the empty root with T and the empty mora with Δ. The presence of any such elements in a candidate form counts as a violation of FILL. The function Gen, which delimits the candidate set corresponding to each underlying representation, will produce every structure that contains the underlying string plus any amount of epenthetic root-nodes, moras, syllables, and so on.

The constraints CODA-COND and FILL are in a relation of *conflict*: there are pairs of competing candidates on which the two constraints disagree. The conflict is crucial, in that one of the candidates is the actual output form, which must emerge as optimal. In such cases, CODA-COND always decides the matter. Therefore, we must have CODA-COND ≫ FILL. This conclusion is illustrated in the following tableau, in which the prefix is suppressed, its place held by ~:

(3) CODA-COND ≫ FILL, from /no-N-*č<sup>h</sup>ik*~wai/

Candidates	CODA-COND	FILL
~.č <sup>h</sup> ik.wai.	* !	
☞ ~.č <sup>h</sup> i.kΔ.wai.		*

The constraint FILL by itself would select the nonepenthetic candidate in (3). But dominant CODA-COND renders FILL irrelevant, and the syllabically well-formed candidate is evaluated as optimal, despite the fact that it contains an empty mora.

Tableau (3) only compares the optimal, epenthetic candidate with another that is completely faithful to the underlying representation. A different species of candidate arises from underparsing of the input, omitting segments from syllable structure, which leads ultimately to their erasure. Nonincorporation of segments into syllables violates PARSE. Here again, we have a conflict: PARSE favors fully syllabified candidates, regardless of whether they contain extra material not present in underlying form, but FILL favors nonepenthetic forms even when they have unparsed segments. In the Axininca Campa Suffix level, the conflict is resolved in favor of PARSE, establishing the necessity of PARSE ≫ FILL:

(4) PARSE >> FILL, from /no-N-č<sup>h</sup>i.k-wai/

Candidates	PARSE	FILL
☞ ~.č <sup>h</sup> i.k <sub>A</sub> .wai.		*
~.č <sup>h</sup> i.<k>.wai.	* !	

PARSE and CODA-COND conflict as well, in principle. PARSE favors syllabified forms, whether or not the syllables in them are well-formed. CODA-COND favors licit syllabifications, whether or not some segments are left out. In this case, however, there is always a candidate that passes both constraints, by virtue of epenthesis (violating FILL), so their potential conflict is moot. This can be seen in the following tableau, which gathers together the comparisons just examined:

(5) /no-N-č<sup>h</sup>i.k-wai/, Full Treatment

Candidates	PARSE	CODA-COND	FILL
☞ ~.č <sup>h</sup> i.k <sub>A</sub> .wai.			*
~.č <sup>h</sup> i.k.wai.		* !	
~.č <sup>h</sup> i.<k>.wai.	* !		

Positing the extra element *A* yields a candidate that passes both PARSE and CODA-COND. The conflict between these two constraints over the treatment of ill-formed candidates is, *as a matter of principle*, of no interest.

Though we have examined only a few stems and a single suffix, the argument just presented applies unchanged to nearly all of the hundreds of C-final stems and perhaps two dozen C-initial suffixes of the language. But because CODA-COND does permit one type of consonant cluster, a syllabically well-formed candidate will arise whenever a nasal-final stem is combined with a stop-initial suffix. In fact morpheme-final nasals do not link with a following stop or affricate. Thus we have, from root /kim/:

(6) /iN-kim~piro-i/ ‘he will really hear’

- a. \*iŋkimpiroT<sub>i</sub>
- b. iŋkim<sub>A</sub>piroT<sub>i</sub>

The failure of simple juxtaposition in (6), and of N+C assimilation in other examples, follows from PARSE, which functions in Axininca Campa with complete generality over all levels of segmental structure. In the present example, linking of the Place nodes of *m* and *p* would satisfy CODA-COND, but it would necessarily violate PARSE. PARSE guards the Place specification of the stem-final nasal against loss, even even when such loss would be phonetically vacuous, as in the case of *m+p*.

PARSE and CODA-COND are in fact never violated. From this general observation, it follows that no constraint crucially dominates either one, since the only evidence for domination is violation. It also follows that any constraint which crucially conflicts with them must be subordinated to them in the ranking. From these considerations, then, we have established the following part of the constraint hierarchy:

(7) PARSE, CODA-COND  $\gg$  FILL

According to this mini-hierarchy, all C+C junctures must be resolved by epenthesis, due to the impossibility of faithful syllabification; and no underlying segment or feature will ever be lost.

#### 4.2 Syllable Structure II: ONSET, ALIGN-L, and ALIGN

The onset is obligatory in Axininca Campa syllables, except word-initially. If the word-initial situation is separated out, we can conclude that the grammar gives high rank to the constraint ONSET, introduced in §2:

(8) ONSET

\*<sub>σ</sub>[V

When morphemic combination brings together /V+V/, faithful heterosyllabic analysis of the V-sequence as V.V is impossible, since it produces an onsetless syllable. All such faithfully-parsed candidates are therefore suboptimal; competing with them are *unfaithful* candidate forms, with unparsed elements or empty structure, which satisfy ONSET. Of these, PARSE violators — with phonetic loss of one or the other of the V's — are never found. This reinforces the assertion, stated above, that PARSE is undominated. FILL-violation, by contrast, is rife.

Thus, the empty root  $\mathbb{T}$  appears pervasively in positions corresponding to input V+V juncture derived from suffixation, as shown in (9), where hiatal morphemic juncture is indicated with  $\sim$ .

(9)  $\mathbb{T}$ -Epenthetic Examples

/i-N-koma $\sim$ i/	iŋkoma $\mathbb{T}$ i	‘he will paddle’
/i-N-koma $\sim$ aa $\sim$ i/	iŋkoma $\mathbb{T}$ aa $\mathbb{T}$ i	‘he will paddle again’
/i-N-koma $\sim$ ako $\sim$ i/	iŋkoma $\mathbb{T}$ ako $\mathbb{T}$ i	‘he will paddle for’
/i-N-koma $\sim$ ako $\sim$ aa $\sim$ i-ro/	iŋkoma $\mathbb{T}$ ako $\mathbb{T}$ aa $\mathbb{T}$ iro	‘he will paddle for it again’
/i-N-č <sup>h</sup> ik-i/	iñč <sup>h</sup> iki	‘he will cut’
/i-N-č <sup>h</sup> ik-aa $\sim$ i/	iñč <sup>h</sup> ikaa $\mathbb{T}$ i	‘he will cut again’
/i-N-č <sup>h</sup> ik-ako $\sim$ i/	iñč <sup>h</sup> ikako $\mathbb{T}$ i	‘he will cut for’
/i-N-č <sup>h</sup> ik-ako $\sim$ aa $\sim$ i-ro/	iñč <sup>h</sup> ikako $\mathbb{T}$ aa $\mathbb{T}$ iro	‘he will cut for it again’

The appearance of  $\mathbb{T}$  satisfies the requirement that syllables have onsets. This means that ONSET dominates FILL in the constraint ranking, as the following tableau demonstrates:

(10) ONSET  $\gg$  FILL, from /iN-koma-i/

Candidates	ONSET	FILL
$\text{[i]} \cdot \text{ij.ko.ma.Ti}$	*	*
$\cdot \text{ij.ko.ma.i}$	** !	

The candidate-comparison here shows that FILL conflicts with ONSET. Since performance on ONSET is decisive, we conclude that ONSET  $\gg$  FILL. Putting the argument in more general terms, one might observe that medially ONSET is never violated, while FILL is; since the two constraints conflict over the comparison of V.TV vs. V.V, ONSET must dominate. Notice that the V.V form violates no other constraints, so it can only be ONSET that is responsible for its demise.

Tableau (10) establishes the ranking of ONSET and FILL, but it is far from a complete account of the optimality of candidates like *ij.ko.ma.Ti*. For one thing, the first syllable of the word incurs a violation of ONSET which could easily be avoided by parsing it with epenthetic T. Yet this is never done. We record this fact in the following observation:

(11) **Initial V.** Axininca Campa has no word-initial epenthesis and freely tolerates initial onsetless syllables.

There is more. Because *ai* is a permissible diphthong of Axininca Campa, it is possible to parse /a+i/ as tautosyllabic, escaping the consequences of *both* FILL and ONSET, yielding \**ij.ko.mai*. Given the constraints we have in hand, this is superior to FILL-violating *ij.ko.ma.Ti*. Such cross-morphemic syllabification is in fact impossible:

(12) **Non-coalescence of /V+V/.** Underlying /V-V/ sequences at stem-suffix juncture are never parsed as tautosyllabic; they always correspond to V.TV at the surface.

The first generalization bans epenthesis; the second requires it. Nevertheless we will see that they devolve from structurally similar conditions on the relation between prosodic and morphological constituency.

Let us first consider the Initial-V phenomenon. This is no fluke: Axininca surface structures are replete with vowel-initial Prosodic Words, in flagrant violation of ONSET; examples are readily found throughout these pages. Furthermore, it is quite common cross-linguistically for languages that otherwise demand strictly C-initial syllables to admit V-initial words. As a bare-faced fact, this observation would seem to require some serious re-writing of ONSET for such languages, restricting its scope so as to exclude PrWd-initial syllables from its purview:

(13) ONSET(EXCEPT)

\* $[\sigma V$  except in the env.  $[\text{PrWd} \text{---}]$

The codicil is specifically crafted so that ONSET(EXCEPT) will not compel FILL-violation in initial position. This will eliminate initial epenthesis, because without a *de jure* violation of ONSET(EXCEPT), violation of FILL cannot be justified.

Parametrizing ONSET is a sorry excuse for *explaining* why V-initial words occur, and it seriously compromises the claim of Optimality Theory that languages differ only in how they rank a fixed set of universal constraints. But parametrizing ONSET is not the only possible approach: the alternative is to bar epenthesis from PrWd-initial position. We propose that the essential constraint is one which relates the prosodic category PrWd to the morphological category Stem, demanding that they begin together. ALIGN-L does precisely that:

(14) ALIGN-L

$$[_{\text{Stem}} = [_{\text{PrWd}}$$

According to this, the left edge of the Stem, which encompasses the root plus any prefixes, must coincide with the left edge of a PrWd.

ALIGN-L should be understood as extending to word-internal constituency the edge-based theory of the syntax/prosody interface (Chen 1987, Clements 1978:35, Hale and Selkirk 1987, Selkirk 1986, Selkirk and Tateishi 1988, Selkirk and Shen 1990). In this theory, the domains of sentence phonology are specified by rules of the general form “the right/left edge of some grammatical constituent coincides with the corresponding edge of some phonological constituent”. With Cohn (1989:199), we propose that the *morphology*/prosody interface is also to be defined in terms of such predicates of edge alignment. The general schema is:

(15) General Schema for ALIGN

In ALIGN(GCat, GEdge, PCat, PEdge), the GEdge of any GCat must coincide with PEdge of some PCat, where

GCat ≡ Grammatical Category, among which are the morphological categories

MCat ≡ Root, Stem, Morphological Word, Prefix, Suffix, etc.

PCat ≡ Prosodic Category ≡ μ, σ, Ft, PrWd, PhPhrase, etc.

MEdge, PEdge = Left, Right

This extends the Chen/Selkirk model in two ways: among the grammatical and prosodic categories subject to alignment are included the word-internal morphological constituents root, suffix, etc. and the word-internal prosodic constituents syllable, foot, etc.; and alignment of *different* edges, required below §4.3.3, may be demanded. As the analysis develops, we will see several more constraints from this family in Axininca Campa grammar. We return to the general issue of the role of alignment constraints in §7 below, and we will find (§7.4) that a special case of alignment, MCAT=PCAT, corresponds to the familiar templates of classical Prosodic Morphology.<sup>27</sup> For conciseness, we often equip constraints of the ALIGN family with informally shortened names in which details of the parameter-list are omitted.

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<sup>27</sup>ALIGN-L (and ALIGN below) echoes the End Rule of Prince (1983) and subsequent developments, such as Mester’s (to appear) account of Latin pre-enclitic accent or, more abstractly, the treatment of boundary tones in Beckman and Pierrehumbert (1988:126f.). It can also be compared to Burzio’s (1992a) purely prosodic principle of Metrical Alignment, “which essentially requires that the [English foot] parsing be left-hand exhaustive.”

ALIGN-L is unviolated and therefore undominated in the constraint hierarchy. ONSET is violated when it conflicts with ALIGN-L; therefore ONSET cannot dominate ALIGN-L. Under our assumptions about ranking, this gives us ALIGN-L  $\gg$  ONSET.<sup>28</sup> The effects on initial C-epenthesis are shown in (16), where the symbol | marks the relevant morphological edge (here, [<sub>Stem</sub>]) and the bracket [ marks the relevant prosodic edge (here, [<sub>PrWd</sub>]).

(16) Failure of Prothesis, from /oti-aanc<sup>h</sup>i/ ‘to put in’

Candidates	ALIGN-L	ONSET	FILL
☞ [  oti~		*	
[ T  oti~	* !		*

The initial T in the losing candidate shifts the PrWd edge away from the Stem edge, causing misalignment of the leading edges of PrWd and stem. Thus, all V-initial stems of Axininca Campa must be parsed in a way that violates ONSET, as required by the dominant constraint ALIGN-L, which bars the otherwise attractive alternative of prothesis.

One aspect of (16) may require clarification, though it presents no real conceptual difficulties. Specifically, the epenthetic T is not part of the stem, since “stem” is a morphological notion, pertaining to the input, while an epenthetic segment is purely phonological, pertaining to the output only. That is, the function Gen, which defines the candidate set, must respect the property called Consistency of Exponence in §2.3. Thus, epenthetic elements have no morphological affiliation in in phonologically-specified morphemes.

The alternative of violating PARSE fares no better than FILL violation does, since an unparsed segment is still a part of the morpheme (and hence the Stem) that sponsors it:

(17) Unparsed Initial Onsetless Syllable

|<o> [ tiTaanc<sup>h</sup>i

Underparsing can never bring a form into agreement with ALIGN-L. For ALIGN-L to be satisfied, the Stem-initial segment, V or C, must occupy initial position in a Prosodic Word. Consequently, an unparsed initial element, which occupies no position in a PrWd, will de-align a stem.

<sup>28</sup>It is also possible to assume that ALIGN-L and ONSET are *unranked* with respect to each other. In this case, *oti~* and *Toti~* in (16) would not be distinguished by the set of undominated constraints, by virtue of each passing one and failing another. The comparison would therefore be passed to the rest of the hierarchy, and FILL would decide the matter in favor of nonepenthesis. Pursuing this line would require extending the theory of constraint satisfaction to deal with properly-partial ordering on the constraint set. At present, when we say that constraints are ‘unranked with respect to each other’, we mean that any order among them will give the same results; the linguistic evidence directly supports a properly partial order, but all totalizations consistent with it are equivalent, so there is nothing crucial about the nonranking. With ONSET and ALIGN-L, however, the facts could be plausibly interpreted to demand only that it *not* be the case that ONSET  $\gg$  ALIGN-L, a ranking which would *force* initial C-epenthesis. Thus, the {ONSET, ALIGN-L} system can be allowed to admit both initial V and initial TV because FILL makes the correct decision independently. We set this refinement aside, however, as a matter for future exploration.

ALIGN-L makes predictions beyond allowing initial onsetless syllables: it forbids all stem-initial epenthesis — vocalic, consonantal, or syllabic — and forbids it for all stems, whether they begin with C or V. This broader prediction holds without exception, and becomes important in the grammar of augmentation to bimoraicity (v. §4.3 (48)). For straightforward empirical reasons, then, it is correct to preserve the pristine constraint ONSET, because the artificially narrowed ONSET(EXCEPT) doesn't begin to tell the whole story about initial epenthesis. ALIGN-L explains why PrWd-initial position should be an apparent exception to ONSET in terms of constraint interaction and the general theory of the prosody/morphology interface. Moreover, it suggests an explanation for why this particular exception should be so common cross-linguistically, since there are obvious functional advantages to having undominated ALIGN-L in the grammar: the first thing you hear is guaranteed to be part of the lexical word.<sup>29</sup> Finally, it supports the claim of Optimality Theory that languages differ only (or principally) in constraint *ranking*, not in the formulation of constraints. Instead of parametrized ONSET, the grammar of Axininca Campa derives a pattern of exceptionality by ranking ALIGN-L above ONSET, where it controls the disposition of V-initial Stems.

The broad scope of ALIGN-L, extending even to the phonology of augmentation (§4.3), differentiates it sharply from the standard analysis of the limitation of onsetless syllables to word-initial position, extrametricality (Spring 1990a:37-44; Black 1991a, 1991b). With ALIGN-L, the analysis presented here treats initial onsetless syllables as fully *intrametrical*, their onsetlessness due to the dominance of ALIGN-L. In §6 we will present a suite of arguments that initial onsetless syllables are indeed intrametrical, in that they participate fully in the prosody of the language. And in §5.2-4 we will show that the other putative consequence of initial extrametricality, non-copying of onsetless syllables in reduplication, follows from the constraint ONSET, which all analyses must invoke. More broadly, Optimality Theory permits a very different perspective on the purported effects of extrametricality in other domains — see fn. 34 (segments), §7 (infixation), Appendix §A.2 and Hung (in prep.) (stress), and especially Prince and Smolensky (1993:§4.3).

A final remark. The role of ONSET in (16) highlights a basic premise of Optimality Theory, the notion of 'minimal violation', as encoded in the principle of Harmonic Ordering of forms (§2.1). Every V-initial word is compelled to violate ONSET at least once, due to the dominance of ALIGN-L. One might be tempted to imagine that ONSET must therefore be irrelevant to the fate of such words, since they cannot but violate it. Evaluation via Harmonic Ordering entails, however, that when a constraint is violated in an optimal form, the extent of

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<sup>29</sup>Another possible effect of ALIGN-L, this time in the phonology of English, has been pointed out to us by Brian O'Herin and Philip Spaelti, on behalf of the UC Santa Cruz Phonology Reading Group. Kahn (1976) observes that word-final consonants are made ambisyllabic before vowel-initial words (i), but word-initial consonants are not made ambisyllabic after vowel-final words (ii):

(i) *sough*[D] Ed (= *sought Ed*)    (ii) *saw* [t<sup>h</sup>]ed (= *saw Ted*)

Flapping of *t* to [D] is assumed to be diagnostic of ambisyllabicity. Thus (i) and (ii) differ crucially in prosodic structure; *t* is ambisyllabic in (i), but it is exclusively an onset in (ii).

The prosodic constraints relevant here are ONSET and FINAL-C (McCarthy, to appear), the latter requiring that PrWd end in a consonant. Form (i) satisfies both ONSET and FINAL-C, and is therefore unproblematic. But (ii) violates FINAL-C; if it were to obey FINAL-C, via ambisyllabification, it would merge with (i). But an ambisyllabic version of (ii) violates ALIGN-L, which requires sharp coincidence of left PrWd and Stem edges. Thus, ALIGN-L >> FINAL-C.

violation will always be strictly limited to the minimum. In the case of ONSET, this means that onsetless syllables in the rest of the word are just as illicit in V-initial as in C-initial words.

Let us turn now to the second issue complicating the ONSET-related patterns. Why is there no tautosyllabification of /V+V/ across morpheme junctures? This would be entirely consistent with the phonology of the language, which recognizes a full system of long vowels in addition to diphthongs *ai* and *oi*. A coalescent form like *\*.ij.ko.mai* violates no phonological constraints at all and is superior, in terms of pure phonology, to the actual epenthetic output *.ij.ko.ma.Ti*, which violates FILL.<sup>30</sup> The grammar must therefore contain a constraint, superordinate to FILL, that dismisses the coalescent candidates.

These facts reflect the fixing of a direct relation between the morphological analysis and the prosodic analysis of a form, closely paralleling that established by ALIGN-L. Observe how, in the following examples, epenthesis guarantees *coincidence* between the end of the stem and the end of a syllable, whereas coalescence places the morphological stem-edge inside a syllable:

#### (18) Stem-Syllable Alignment

- |                    |                       |
|--------------------|-----------------------|
| a. /iN-koma~i/     | .ij.ko.ma .Ti.        |
|                    | *.ij.ko.ma i.         |
| b. /iN-koma~ako~i/ | .ij.ko.ma .Ta.ko .Ti. |
|                    | *.ij.ko.ma a.k.o i.   |

The relevant stem-edge is marked, as before, with the sign |. Example (18), with stems *iN-koma-* and *iN-koma-ako-*, shows that suffixation creates a new Stem category, recursively, just as promised in §3 above.

The distinction between matching and non-matching syllable/stem edges is embodied in the constraint we will call simply ALIGN.<sup>31</sup> This constraint was first introduced in Prince and Smolensky's (1991b, 1993) analysis of Lardil.<sup>32</sup>

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<sup>30</sup>Henrietta Hung reminds us that heteromorphemic identical vowels cannot be fused into a true (singly-linked) long vowel without leaving one of the vowel melodemes unassociated, in violation of PARSE (cf. discussion of (6)). If a similar explanation could be provided for the failure of *a+i* and *o+i* to fuse into diphthongs, then there would be no issue here. But to make this explanation work, *ai* and *oi* must be represented as complex segments of some sort, with a single root node. It is difficult to imagine what such a representation would be, since *a* and *o* share no place features with *i*, and there is no evidence for this representation in Axininca Campa, which lacks breaking rules, light diphthongs, and other evidence for a complex segment analysis.

<sup>31</sup>In work antedating the present era, Yip (1983:244-5) proposed that Axininca epenthesis is "morphological" because it is limited to verb suffixation and because it breaks up syllables that would otherwise be permissible. The morphological condition is encoded via an ALIGN-like restriction in the contexts of two separate epenthesis rules (slightly simplified here):

$$\begin{array}{l} \emptyset \rightarrow t / \text{V}]_{\text{verb}} + \text{ \_\_\_\_\_\_ } \text{V} \\ \emptyset \rightarrow a / \text{C}]_{\text{verb}} + \text{ \_\_\_\_\_\_ } \text{C} \end{array}$$

One liability of this account is the appearance of an arbitrary and unexplained morphological condition in two formally unrelated epenthesis rules. Another is its lack of connection with the syllabic determinants of epenthesis.

According to Dressler (1985:321), resyllabification across morpheme boundaries is one of the factors affecting "morphotactic transparency", though supposedly more weakly than morphophonemic alternation and allomorphy. But Dressler presents no analysis in support of the relative strength of these factors or in support of a specific role for resyllabification. (Thanks to Greg Iverson for pointing out this reference.)

<sup>32</sup>The phenomena motivating ALIGN recall the situation in the Australian languages Diyari and Yidiø, where morphological and prosodic constituent-edges must also coincide. Poser (1989) and Hewitt (1992) propose cyclic

## (19) ALIGN

$$]_{\text{Stem}} = ]_{\sigma}$$

Framed within the same extension of the Chen/Selkirk model as ALIGN-L, this constraint says that every final stem-edge matches to a final syllable-edge. To be fully accurate, the constraint should explicitly mention the universal quantification over stem-edges and the existential quantification over syllable-edges, or be phrased in terms of the theory of ALIGN-type constraints in (15),  $\text{Align}(\text{Stem}, \text{Right}, \text{Syllable}, \text{Right})$ , but the concise statement in (19) is more memorable.

When prosodic minimality is at issue in Lardil, the constraint ALIGN functions in the Prince and Smolensky analysis to regulate the extent of augmentation, explaining the contrast between the patterns in (20). (Lardil also shows the effects of ALIGN-L, since augmentation is final, not initial.)

## (20) Align in Lardil

a. /yak/	.ya.k  $\mathbb{A}$ .	‘fish’
b. /mar/	.mar .T $\mathbb{A}$ , *.ma.r  $\mathbb{A}$ .	‘hand’

Lardil syllables don’t end on *k*, forcing misalignment of /yak/ in (20a). The root /mar/ in (20b), by contrast, is susceptible to syllabification in its entirety. As a consequence, augmentation is driven beyond the absolute minimum: we find T $\mathbb{A}$  where  $\mathbb{A}$  would suffice to provide the basis for the required second syllable.

As in Lardil, ALIGN in Axininca is ranked above FILL, forcing the otherwise unmotivated appearance of empty structure. In Lardil, we find T $\mathbb{A}$  where  $\mathbb{A}$  would do, a double violation instead of a single one. In Axininca Campa we find epenthesis of T where faithful epenthesis-free syllabification would suffice to give satisfactory phonology. The following tableau makes this clear:

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treatments of this phenomenon in Diyari and Yidiø, respectively (similar to Spring and Black’s cyclic analyses of Axininca Campa, discussed below). Goldsmith (1991:262-3), commenting on Poser’s analysis of Diyari, observes that the same facts can be treated non-cyclically in terms of constraint satisfaction.

ALIGN-like treatments of apparently cyclic stress phenomena have been proposed, starting with Liberman and Prince’s (1977) account of English phrasal and compound stress. Halle and Kenstowicz (1991) propose to reify the foot-boundary, giving an analysis of Diyari in which a rule inserts a left foot-bracket symbol at the beginning of each morpheme; Idsardi (1992) parametrizes this approach over a data base of stress and accent systems. (The notion of alignment developed here works from constituency and eschews the reification of boundary symbols that the ‘insertion rule’ conception depends on (Siegel 1974, Rotenberg 1978).) The prosodic subcategorization approach of Inkelas (1989), though affix-based, deals with prosody-morphology relations in a way that is broadly similar to alignment. Finally, as noted above, the formula  $\text{MCAT}=\text{PCAT}$ , “morphological category corresponds to phonological category,” of McCarthy and Prince (1991a), amounts to demanding a kind of alignment at both edges; we take up this matter below in §7.4.

(21) ALIGN  $\gg$  FILL, from /iN-koma-i/

Candidates	ALIGN	FILL
☞ .iŋ.ko.ma .Ti.		*
.iŋ.ko.ma i.	* !	

With this ranking, failure to meet ALIGN dooms the coalescent form. because the candidates agree on all other constraints besides ALIGN and FILL.

It is possible to circumvent *both* ALIGN and FILL, but only at the cost of incurring additional violations.

(22) Losing Candidates Satisfying ALIGN and FILL

Candidates	PARSE	ONSET	ALIGN	FILL
a. ☞ .iŋ.ko.ma .Ti.		*		*
b. .iŋ.ko.ma i.		** !		
c. .iŋ.ko.ma .⟨i⟩	* !	*		

The additional candidates considered in (22) are no improvement:

- Proper alignment can be obtained by syllabifying /V+V/ as V.V, at the cost of violating ONSET (22b). Because ONSET  $\gg$  FILL, as shown in (10), this is fatal.
- Alignment may also be obtained by underparsing (the affix, not the stem), as in (22c); fatal again, because PARSE  $\gg$  FILL, as shown in (4).

Putting the arguments (21) and (22) together, we have shown that the output from /V+V/ must be V.TV, as desired. These facts depend only on the subordination of FILL, so that the ranking justified so far is this:

(23) PARSE, ONSET, ALIGN  $\gg$  FILL

Up to this point, we have only considered the consequences of ALIGN for /V+V/ sequences. To fully secure our results, we must consider the other possible combinations of tauto- and heteromorphemic segments. The remaining types of underlying segment sequences fall into two classes: those that pose no problems at all for ALIGN (tautomorphemic; V+C); and those that pose problems that are completely insoluble (C+V; C+C).

First, the easy case of simple satisfaction. Vacuous: morpheme-internal segment sequences X<sup>∩</sup>Y do not invoke ALIGN, because their juncture is away from the stem-edge. In particular, tautomorphemic long vowels and the diphthongs *ai* and *oi* remain intact, since they are not subject to ALIGN or to any other constraint that would sanction FILL-violation. Nonvacuous: underlying /V+C/ sequences syllabify faithfully as V|.C, meeting ALIGN while maintaining perfect, faithful phonology. Suffixation with the continuative /-wai/ provides an example:

## (24) V+C juncture

/in-koma~wai~/ .ij.ko.ma|.wai.~ ‘... continue to paddle’

Heteromorphemic sequences /C+V/, and /C+C/, by contrast, fall into the irresolvable category: they can never give rise to an optimal candidate in which proper alignment is observed. In the case of /C+C/, it is clear that the faithful properly-aligned analysis C|.C is hopeless. No morpheme-final C is ever syllabifiable as a coda, as shown above in §4.2. This means that CODA-COND is in direct conflict with ALIGN in the /C+C/ cases. It is the unviolated CODA-COND, of course, that dominates.<sup>33</sup>

(25) CODA-COND >>ALIGN, from /no-N-č<sup>h</sup>ik-wai/

Candidates	CODA-COND	ALIGN
☞ ~.č <sup>h</sup> i.k A.wai.		*
~.č <sup>h</sup> ik .wai.	* !	

The insertion of ALIGN into the grammar therefore has no consequences for the analysis of /C+C/ juxtaposition. The conclusion is secure that /C+C/ corresponds to CΔC in the optimal candidate. With PARSE undominated, there can be no reason to except material from syllabic analysis, and FILL-violation is compelled. The following tableau illustrates the argument with an additional, underparsed candidate:

(26) Necessity of Epenthesis, /no-N-č<sup>h</sup>ik-wai/

Candidates	PARSE	CODA-COND	ALIGN	FILL
☞ ~.č <sup>h</sup> ikΔwai			*	*
~.č <sup>h</sup> ik .wai.		* !		
~.č <sup>h</sup> i.(k) wai.	* !		*	

Note that underparsing, as in the last candidate, can never bring a form into agreement with ALIGN. For ALIGN to be satisfied, the morpheme-final C must occupy final position in a syllable. Consequently, an unparsed final element will de-align a morpheme. (Compare the same result with respect to ALIGN-L in (17) above.) This means that PARSE and ALIGN cannot be directly ranked with respect to each other. PARSE is undominated, however, and violation of it is inevitably fatal, since alternatives always exist that satisfy it: epenthetic forms, for example, when faithful parsing is impossible.

<sup>33</sup>The configuration in (25), in which an interface constraint is dominated by a purely prosodic constraint, is an important one in the theory of constraint ranking in Prosodic Morphology — see §7.2. Compare also Selkirk (1993), in which an interface constraint is crucially dominated by another interface constraint.

The remaining heteromorphemic sequence /C+V/ is also doomed to misalignment. The phonologically natural parse is .C|V., ending the morpheme mid-syllable, and there's no way out. Epenthesis is futile:

- ~.C|A.TV is still misaligned.

It's always possible to do worse:

- ~.C|A.V is misaligned and fails ONSET too.

The only way to achieve proper alignment is by sacrificing undominated constraints on syllabic well-formedness, hardly a viable option:

- ~C|.V manages to violate both ONSET and CODA-COND;
- ~C|.TV fails CODA-COND.

The conclusion is that ALIGN can have absolutely no effect on the parsing of the input sequence C+V.

The force of these observations is seen concretely in the following tableau:

(27) /č<sup>h</sup>ik+aanc<sup>h</sup>i/ 'to cut (infinitive)'

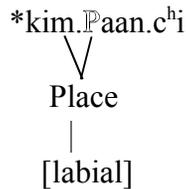
Candidates	ONSET	CODA-COND	ALIGN	FILL
a.  .č <sup>h</sup> i.k aan.c <sup>h</sup> i.			*	
b. .č <sup>h</sup> ik .aan.c <sup>h</sup> i.	* !	* !		
c. .č <sup>h</sup> ik .Taan.c <sup>h</sup> i.		* !		*
d. .č <sup>h</sup> i.k A.aan.c <sup>h</sup> i.	* !		*	*
e. .č <sup>h</sup> i.k A.Taan.c <sup>h</sup> i.			*	** !

Of these, (b) and (c) purchase alignment in exchange for syllabic ill-formedness, a fool's barter. This entails that the optimal candidate must be misaligned. Candidate (d) is both syllabically ill-formed and misaligned. Candidate (e) succeeds syllabically, is equal in misalignment to the optimal candidate, but loses on FILL, due to the presence of epenthetic elements that have no justification, as they do not render it more harmonic than the simple faithful parse.

Because CODA-COND *does* permit nasal+stop clusters, there is an additional serious candidate to consider in the case of nasal-final stems like /kim/: \*kim|.Paan.c<sup>h</sup>i (for actual ki.m|aan.c<sup>h</sup>i 'to hear'). To assess this form correctly, we must be explicit about how it is represented. There are two possibilities, depending on precisely how Gen, the function that delimits the candidate set, is stated. As it happens, neither candidate is optimal, so the ill-formedness of \*kim|.Paan.c<sup>h</sup>i is stable over the range of plausible technical decisions.

Suppose first of all that Gen supplies a candidate with an assimilated Place node, represented essentially as in (28):

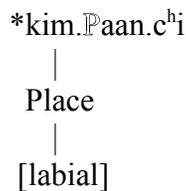
(28) \**kimPaanc<sup>h</sup>i*, With Linking



This form is mis-ALIGNED, because the Place node of the *m*, obviously part of the representation of the Stem, is syllabified, via *P*, in the onset of the second syllable. ALIGN requires sharply-defined morpheme edges, but linking, as in (28), undoes the desired relation between the morphological and prosodic constituency of a form.

Suppose instead that Gen supplies a candidate without linking, so that *P* is represented as nothing more than a bare root node, to be interpreted as [labial] by some other component of the grammar:

(29) \**kimPaanc<sup>h</sup>i*, Without Linking



This representation is in violation of CODA-COND, since the medial NC cluster is not homorganic. A full formalization of CODA-COND, along the lines of Itô (1986, 1989), would require linking as the formal prerequisite to homorganicity.

Now that we have fully explored the implications of ALIGN for suffixation, a comparison with alternatives is appropriate. The facts in (9) that motivate ALIGN have been previously regarded as evidence of cyclic syllabification (Spring 1990a:52-53, 161-162; Black 1991a:205). The cyclic account of this pattern relies on the assumption that a syllable formed on one cycle is *closed* to the addition of further segments on later cycles. For example, in *ij.komaTi*, the cyclic domain *.ij.ko.ma.* is fully syllabified as shown; the suffix *i* that is present on the next cycle cannot be added to the syllable *ma*, which is now closed.

The failure of coalescence at morpheme juncture is the only evidence for cyclic rule application in Axininca Campa. (Another potential case, involving the phonology of the velar glide, is discussed in the Appendix.) Even granting the possibility of having cyclic syllabification with no other cyclic prosody, the specific details of this analysis are not compatible with other properties that have been attributed to the cycle in the literature. Steriade (1988b:309-10) has argued that closure is **not** true of cyclic syllabification (though she holds that it is true of cyclic foot assignment). Furthermore, Inkelas (1989:59-66) and others have argued that bound roots are not cyclic domains. Axininca Campa verbal roots are bound (Payne 1981:19), yet they must be cyclic domains to make the analysis work. Like suffixes, Axininca bound roots evince the closure property whether or not they have undergone previous affixation.

In contrast to the cycle, whose effects are limited to the facts in (9), ALIGN has significant consequences for the augmentation of subminimal roots (§4.3 (43), §5.2 (28), §5.4 (72)) and for the shape of reduplicative copies (§5.2 (14, 25)). From a broader perspective, ALIGN and similar

constraints provide an immediate account of the familiar observation that cyclicity is typically **only** a property of prosody. This was first noted by Brame (1974:58-9), but has never been satisfactorily explained. If apparent cyclicity is a result of ALIGN-like constraints requiring coincidence of the edges of morphological and prosodic constituents, then “cyclic” effects are necessarily limited to prosody and segmental phenomena dependent on prosody.<sup>34</sup>

In this section, we have seen how the onset requirement of Axininca Campa forces aggressive analysis at V+V junctures. In concert with ALIGN, which is part of the morphology-prosody interface in the language, the constraint ONSET compels the positing of an empty consonantal root  $\mathbb{T}$ . This ensures an onset for the suffix-initial V at the same time as it guarantees proper stem/syllable alignment, with the final segment of the stem sitting in syllable-final position.

We have also seen how the onset requirement is attenuated PrWd-initially by the dominant constraint ALIGN-L. Though ONSET by itself would force the epenthetic consonantal root node  $\mathbb{T}$  everywhere, initial epenthesis is impossible because it violates the competing requirement that the left edge of the PrWd truly represent the left edge of the underlying Stem. PrWd and Stem must begin together, and brook no interlopers.

These results depend on four crucial rankings, displayed here:

### (30) New Rankings

Rankings	Effects
ONSET $\gg$ FILL	Epenthesis to provide onset (10)
ALIGN $\gg$ FILL	Epenthesis, not coalescence, at V+V juncture, *.Ca i. (21)
CODA-COND $\gg$ ALIGN	Syllable well-formedness not sacrificed to get alignment (25)
ALIGN-L $\gg$ ONSET	No epenthesis in Stem-initial position <sup>35</sup> (16)

Putting all these together with previous results will yield the following sets of crucial rankings:

<sup>34</sup>ALIGN supplants not only some applications of the cycle, but also, as Greg Iverson and Kelly Lietz have pointed out to us, much of segmental extrametricality. Consider a language like Kamaiurá (see §7.3 below and Everett and Seki 1985), in which syllables are strictly open except word-finally, where a single consonant can occur: *apot*. This phenomenon is standardly analyzed with a maximal CV syllable and final-consonant extrametricality (e.g., Borowsky 1986, Itô 1986, 1989, Rice 1989). ALIGN permits an alternative conception. As shown in §2.2, in a language with only open syllables NOCODA is dominant, and the core of the syllabic phonology is either NOCODA  $\gg$  PARSE (16) or NOCODA  $\gg$  FILL (19). But if NOCODA is itself dominated by ALIGN, then the rightmost segment of the stem must be faithfully parsed even if it leads to a NOCODA violation:

Candidates	ALIGN	NOCODA	FILL	PARSE
☞ .a.pot		*		
* .a.po.<t	*!			*
* .a.po.t A.	*!		*	

<sup>35</sup>See fn. 28 for discussion of the possibility of non-ranking of these constraints.

(31) Crucial Ranking Sequences<sup>36</sup>

- a. PARSE, ONSET  $\gg$  FILL
- b. CODA-COND  $\gg$  ALIGN  $\gg$  FILL
- c. ALIGN-L  $\gg$  ONSET

This can be flattened into a single hierarchy with no change of predictions:

## (32) Conflated Hierarchy

PARSE, CODA-COND, ALIGN-L  $\gg$  ONSET, ALIGN  $\gg$  FILL

The unviolated constraints cannot be crucially ranked with respect to one another because all domination arguments are based on violation; any domination order among them gives the same results. ONSET and ALIGN cannot be ranked with respect to one another because of the lack of crucial conflicts; CODA-COND always intervenes in the argument, as in (27). Because the unviolated constraints have been gathered together, the conflated hierarchy (32) asserts several rankings that, though harmless, are not crucial, again because of the lack of direct conflict. These include the ranking of PARSE and ALIGN-L above ALIGN and the ranking of CODA-COND over ONSET. What's important is that PARSE, CODA-COND, and ALIGN-L are undominated, so that violation of them cannot be compelled under any conditions.

The striking feature of the explanation developed here is that there is absolutely no mention of the specific /V+V/ environment in which  $\mathbb{T}$ -epenthesis is observed. The constraint ALIGN is entirely general, making no reference to particular segment-types or to following context. We repeat it here for convenience:

## (33) ALIGN

$$]_{\text{stem}} = ]_{\sigma}$$

This constraint demands no more than coincidence of certain morphological and prosodic edges. Its consequences will therefore vary from language to language, depending on further morphological and phonological particularities. In Lardil, for example, it forces closure of the stem syllable, when licit, as shown in (20), but in Axininca Campa it forces epenthesis into a following syllable.

Not only are specific segmental conditions absent from the grammar of the language; even the *induction* of the ALIGN-relevant rankings requires only limited examination of segmental environments. ALIGN dominates FILL because alignment can compel epenthesis in the face of a nonepenthetic candidate: /V+V/ leads to VTV rather than to tautosyllabic VV. CODA-COND dominates ALIGN because coda well-formedness cannot be sacrificed anywhere, a simple observation about the surface of the language. The treatment of the entire range of segmental juncture-types {tautomorphemic; V+V, V+C, C+V, C+C} then follows.

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<sup>36</sup>PARSE  $\gg$  FILL is justified in (4) §4.1. CODA-COND  $\gg$  FILL follows from transitivity of  $\gg$ , but is justified directly in (3) §4.1.

The explanation for the legitimacy of initial onsetless syllables has exactly the same character. There is no mention at all of *syllable structure* in the constraint ALIGN-L, which governs initial position:

(34) ALIGN-L

$$[_{\text{Stem}} = [_{\text{PrWd}}$$

The constraint demands that PrWd and stem begin together, regardless of stem segmentalism. No trick, this correctly rules out all initial epenthesis, including that provoked by prosodic minimality requirements (§4.3 below), which are quite insensitive to onsets. Nor is there mention of *initial position* in the syllabic constraint ONSET; again, this is entirely correct, since hanging extra conditions on the constraint would only address the C-epenthesis subphenomenon. Instead of having a messy theory of epenthesis sitting inertly alongside of a messy theory of onsets, we have clean theory of onsets coupled productively to a clean theory of the prosody-morphology interface.

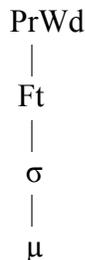
It is the possibility of interaction, then, that allows us to build individual grammars directly from a set of very general constraints made available by Universal Grammar. Optimality Theory is essential to the construction, defining the nature and consequences of the interactions. The constraint ALIGN, for example, is violated in half the junctural environments to which it is relevant. It would be excluded *a priori* from consideration in any theory which takes phonotactic truth as criterial for laws of linguistic form. Even the constraint ONSET, the very touchstone of syllabic well-formedness, would have to be modified ad hoc into ONSET(EXCEPT) in order to satisfy the demands of phonotacticism. With interaction, however, the desired behavior is an emergent property of the grammar and the complexities of epenthesis (‘insert  $\mathbb{T}$  *only* to provide an onset’; ‘*except* word-initially’) are consequences of the domination relation holding between authentically general principles.

## 4.3 Augmentation and Alignment

### 4.3.1 The Prosodic Theory of Minimality

The Prosodic Morphology Hypothesis requires that templatic restrictions be defined in terms of prosodic units. The Prosodic Hierarchy in (35), evolved from that of Selkirk (1980a, 1980b), specifies what those units are:

(35) Prosodic Hierarchy



The units of prosody are the mora  $\mu$ , the syllable  $\sigma$ , the metrical foot Ft, and the Prosodic Word PrWd. The mora is the familiar unit of syllable weight (Prince 1980, van der Hulst 1984, Hyman 1985, McCarthy and Prince 1986, Hayes 1989, Itô 1989, etc.). Monomoraic syllables are light and bimoraic ones are heavy.

Metrical feet are constrained both syllabically and moraicly. The inventory laid out in (36) below is proposed in McCarthy and Prince (1986) and Hayes (1987) to account for Hayes's (1985) typological findings. (Subsequent work along the same lines includes Hayes (1991), Kager (1989, 1992a, 1992b, 1992c), Prince (1991), Mester (to appear), and others.) We write *L* for light syllable, *H* for heavy syllable.

(36) Foot Types

Iambic	Trochaic	Syllabic
LH	H, LL	$\sigma\sigma$
LL, H		

Conspicuously absent from the foot typology are degenerate feet, consisting of just a single light syllable, though they may play a marked role in stress assignment (Kager 1989, Hayes 1991, but see Kiparsky 1992). The following general condition on foot form is responsible for the nonexistence (or markedness) of degenerate feet (Prince 1980, McCarthy and Prince 1991a):

(37) Foot Binariness (FTBIN)

Feet must be binary under syllabic or moraic analysis.

The Prosodic Hierarchy and Foot Binariness, taken together, derive the notion "Minimal Word" (Prince 1980, Broselow 1982, McCarthy and Prince 1986, 1990a, 1991a, 1991b). According to the Prosodic Hierarchy, any instance of the category Prosodic Word (PrWd) must contain at least one Foot (Ft). By Foot Binariness, every Foot must be bimoraic or disyllabic. By transitivity, then, a Prosodic Word must contain at least two moras or syllables.

In a quantity-insensitive system, where syllable-internal moraic structure is irrelevant, the Minimal Word will be a disyllable. In a quantity-sensitive prosody, by contrast, the Minimal Word is bimoraic *tout court*, a pair of light syllables or a single heavy one. Observed word minimality restrictions therefore follow from the grammatical requirement that a certain morphological unit, often Stem or Lexical Word, must correspond to a Prosodic Word. (See §7 for further discussion.)

This notion of word minimality turns out to have broad cross-linguistic applicability; see among others McCarthy and Prince (1986, 1991a), Cho (1992), Cole (1990), Crowhurst (1991), Dunlap (1991), Hayes (1991), Itô (1991), Mester (1990, to appear), Itô, Kitagawa, and Mester (1992), Itô and Mester (1992), McDonough (1990), Spring (1990a, 1990b), Orgun and Inkelas (1992), Piggott (1992), Tateishi (1989), Weeda (1992), and Yip (1991). One particularly striking case occurs in the Australian language Lardil; it was first analyzed in these terms by Wilkinson (1988) based on work by Hale (1973) and Klokeid (1976); Kirchner (1992a) offers further analysis.

In Lardil, CVV(C) syllables are heavy or bimoraic, while CV(C) syllables are light. Lardil prosody is quantity-sensitive and a stem must be PrWd. The entailed bimoraic minimum

is responsible for the following alternations, which involve both augmentation and truncation phenomena:

## (38) Lardil

Underlying	Nominative	Accusative	Gloss
a. Bimoraic Base			
/wiʔe/	wiʔe	wiʔe-n	‘inside’
/peer/	peer	peer-in	‘ti-tree sp.’
b. Monomoraic Base			
/wik/	wik <sup>A</sup>	wik-in	‘shade’
/ter/	ter <sup>A</sup>	ter-in	‘thigh’
c. Long Bases			
/mayara/	mayar	mayara-n	‘rainbow’
/kantukantu/	kantukan	kantukantu-n	‘red’

Bimoraic roots remain unchanged in the nominative (38a). But subminimal monomoraic ones are augmented to two moras (38b), guaranteeing licit PrWd status. Final vowels are deleted in the nominative — left unparsed, in present terms — with consequent loss of whatever consonants are thereby rendered unsyllabifiable, shown in (38c). Final vowels are, however, preserved in stems like *wiʔe*, which could not be made any shorter and still fulfill the minimality requirement. In Lardil, constraints on PrWd well-formedness therefore both promote augmentation (FILL violation) and inhibit truncation (which involves violation of PARSE). Optimality Theory provides the analytical tools needed to make sense of such complex interactions; a complete analysis is presented in Prince and Smolensky (1991b, 1993).

The minimal Prosodic Word also functions in prosodic morphology, in two different roles. In the Australian language Diyari (Austin 1981, McCarthy and Prince 1986, Poser 1989), the minimal Prosodic Word is the template for a process of prefixing reduplication.

## (39) Diyari Reduplication

Singular	Plural	
wila	<u>wila</u> -wila	‘woman’
ŋankanti	<u>ŋanka</u> -ŋankanti	‘catfish’
tʰilparku	<u>tʰilpa</u> -tʰilparku	‘bird sp.’

The reduplicated string in Diyari is exactly two syllables long, in conformity with the quantity-insensitive prosody of the language. Like any PrWd of Diyari, the reduplicative morpheme must be vowel-final. This explains why the last two examples shun the forms \**ŋankan-ŋankanti* and \**tʰilpar-tʰilparku*, which are reduplicatively superior because of more complete copying of the base.

In another Australian language, Yidiø (Dixon 1977), the minimal word is the base to which total reduplication applies (McCarthy and Prince 1990a).

## (40) Yidiø Reduplication

Singular	Plural	
.mu.la.ri.	<u>mula</u> -mulari	‘initiated man’
.tʰu.kar.pa.	tʰ <u>ukar</u> -tʰukarpa-n	‘unsettled mind’
.kin.tal.pa.	<u>kintal</u> -kintalpa	‘lizard species’
.ka.la. <sup>m</sup> pa.ɽa.	<u>kala</u> -kala <sup>m</sup> paɽa	‘March fly’

In Yidiø, the disyllabic minimal PrWd *within* the noun stem is targeted and copied completely. The syllabification of the stem determines whether the PrWd so obtained is V-final, like *mula* from *mulari*, or C-final, like *kintal* from *kintalpa*. The Optimality-Theoretic interpretation of such effects is discussed in §7 below.

## 4.3.2 ALIGN and ALIGN-L

Identifying a morphological unit like *Stem* as a *Prosodic Word* has, then, characteristic consequences for the size and shape of the unit. In Axininca Campa, under certain conditions, short roots /CV/ and /C/ are augmented to bimoraicity. Previous work has attributed this to the notion Minimal Word (Itô 1989:239; Spring 1990a:140-163, 1990b:501, 1991:7-8, 1992:5-7; Black 1991a:202-204, 1991b:10). Our goal is to extend this basic insight to cover all cases where augmentation is required.

The characteristics of augmentation in Axininca Campa are fully exemplified in the forms gathered in table (41), using the roots *na* ‘carry on shoulder’ and *p* ‘feed’ in combination with the suffixes *-aanc<sup>hi</sup>* ‘infinitive’, *-piro* ‘verity’, and *-RED* ‘more and more’:<sup>37</sup>

## (41) The Augmentation System

Root		__+V...	__+C...	__+RED
/na/	<i>Aug.</i>		naTA-piroTaanc <sup>hi</sup>	naTA-naTA-waiTaki
	<i>Nonaug.</i>	na-T-aanc <sup>hi</sup>	no-na-piroTi	no-na-nona-waiTi
/p/	<i>Aug.</i>		pAA-piroTaanc <sup>hi</sup>	pAA-pAA-waiTaki <sup>38</sup>
	<i>Nonaug.</i>	p-aanc <sup>hi</sup>		no-wA-nowA-waiTi

<sup>37</sup>The alternations exemplified by /na/ are typical of monomoraic roots like /to/ ‘cut the hair’, /tʰo/ ‘kiss, suck’, and /si/ ‘defecate’. The alternations exemplified by /p/ are typical of monoconsonantal roots like /ɛ/ ‘enter’, /ñ/ ‘see’, and /ñ/ ‘talk’. The example *pAA-piroTaanc<sup>hi</sup>* is not directly attested in our sources, but was constructed on the basis of the equivalent form *ñAA-piroTaanc<sup>hi</sup>* from the root /ñ/ (Spring 1990c:149). The example *om-pA-waiTiroota* ‘she might continually feed to her/it’ (Payne 1981:242) confirms that monoconsonantal roots like /p/ do not augment when prefixed.

<sup>38</sup>These forms are only known from the “Axininca 2” dialect data collected by Payne and Spring in 1989 (cf. fn. 59).

Augmentation is to bimoraicity, as expected, since the prosody of the language is quantity-sensitive. Less obvious are the conditions under which augmentation occurs and the form taken by the epenthetic elements. Three factors determine the outcome:

i. **Bareness.**

Only a bare root is augmented.

When a prefix is present, nothing happens.

ii. **Syllabicity.**

Roots /CV/ augment to disyllabic CVTA.

Roots /C/ augment to form a single heavy syllable CAA.

iii. **Suffix-initial C** (Payne 1981:145)

Subminimal roots augment when reduplicated or when followed by a C-initial suffix;

Roots do not augment when followed by a V-initial suffix.

Of these three conditions, the first two are grounded in grammatical properties quite independent of augmentation. Condition (i), *Bareness*, reflects the fact that Prefix and Root join together to form a unit *Stem*, already known from the Lexical-Phonological organization of the language (§3). When a PrWd requirement falls on the *Stem*, any prefix that is present must count toward satisfying it.

Condition (ii), *Syllabicity*, might seem more puzzling, but it follows directly from the constraint ALIGN (19) and the rankings already established. For convenience, we repeat the statement of the constraint:

(42) ALIGN

$$]_{\text{Stem}} = ]_{\sigma}$$

ALIGN requires that every right stem-edge coincide with the right edge of a syllable; equivalently, that the stem-final element be also syllable-final.

Consider first stems /CV/ like *na* ‘carry’. There are three essential patterns of minimal augmentation to examine:

(43) Augmentation of /CV/

- |                  |          |
|------------------|----------|
| a. Monosyllabic: | *.na A.  |
| b. Disyllabic:   | *.na .A. |
| c. Disyllabic:   | .na .TA  |

Only the addition of the full syllable TA, as in (43c), gives both proper alignment and syllabic wellformedness. The minimally augmented form (43b) grossly violates ONSET, dooming it through comparison with the other forms. The monosyllabic pattern is misaligned; the morpheme ends amid the long vowel.

The following tableau certifies the argument:

## (44) Augmentation of /na/

Candidates	ONSET	ALIGN	FILL
 .na .TA.			**
.na A.		* !	*
.na .A.	* !		*

Note that the crucial domination relation  $ALIGN \gg FILL$  is already established. Since Axininca Campa has both underlying and derived long vowels,<sup>39</sup> it can only be ALIGN that eliminates the FILL-conservative monosyllabic form *naA*. Just as with heteromorphemic V+V sequences discussed above in §4.2 (21), ALIGN forces otherwise unjustifiable violations of FILL.

This argument rests on the claim that the candidate (43a), phonetically realized as [na:], is misaligned. This is pre-theoretically reasonable: after all, the root /na/ ‘carry on shoulder’ contains a short vowel, contrasting minimally with /na:/ ‘chew’, and the extra mora comes from the phonology. The proposed explanation turns on the contrast between what is motivated lexically and what is motivated phonologically, which any theory will recognize in some way. The representational assumptions of §2.3 yield a particularly straightforward account. Lexically, vowels come with their moras attached; we are dealing then with /n[a]<sub>μ</sub>/. In the environment where augmentation is required, an empty mora will be posited in the candidate under consideration:

## (45) Augmented Parse of /na/



The morpheme-final element [a]<sub>μ</sub> is not in syllable-final position: the branch of the  $\sigma$ -tree dominating material from the morpheme does not coincide with the rightmost branch of  $\sigma$ . Hence, ALIGN is violated.

ALIGN alone has nothing to say about the *location*, fore or aft, of the supplied syllable. Equally satisfactory alignment is obtained whether epenthesis be initial or final:

## (46) Syllabic Augmentation Possibilities

- a. .na|.TA.
- b. .TA.na|.

<sup>39</sup>Two sources of derived long vowels not discussed here are the Lengthening rule of Payne (1981:137), which lengthens vowels after heteromorphemic palatal consonants, and the Subjunctive Lengthening rule of Payne (1981:150), which lengthens a vowel before the subjunctive suffix *-ta*.

But, of course, no epenthesis of any kind ever occurs at the beginning of words because of ALIGN-L, which governs *left* edges.

## (47) ALIGN-L

$$[_{\text{Stem}} = [_{\text{PrWd}}$$

ALIGN-L is unviolated and therefore undominated in the constraint hierarchy. Its effects on syllabic epenthesis are shown here, with the sign | used to mark the initial edge of the stem and the simple bracket [ used to mark the PrWd edge:

## (48) Initial Alignment Dooms Initial Augmentation

- |            |        |
|------------|--------|
| a. [  naTA | ↔ naTA |
| b. [ TA na | * TAna |
| c. [ A na  | * Ana  |

These data show, as promised above in §4.3.1 (p. 36), that the non-initiality of epenthesis has nothing to do with the constraint ONSET. The issue here is bimoraicity; the root /na/ forms an unimpeachable syllable. ALIGN-L is part of the language no matter what further remarks apply to syllable structure.

Monoconsonantal roots /C/ pose a different range of problems for ALIGN — problems that are irresolvable. For them, there is no analysis that simultaneously obtains both syllabic well-formedness and proper alignment. To see this, consider the following reasonable candidates, all of which achieve bimoraicity:

## (49) Augmentation of /C/

a. *End-aligned*

.AC|.
  
.TAC|.

b. *End-misaligned*

- |      |          |
|------|----------|
| i.   | .A.C A.  |
| ii.  | .TA.C A. |
| iii. | .C A.TA  |
| iv.  | .C AA.   |

The only candidates with proper end-alignment are in (49a). By virtue of proper alignment they violate CODA-COND, sufficient for elimination. On top of that, they display initial epenthesis in violation of ALIGN-L (47), also sufficiently fatal. Of the remaining four candidates, neither mono- nor disyllabic modes of epenthesis have any effect whatever on the fundamental misalignment. Initial epenthesis, as in (49bi, ii) is impossible, of course. This leaves only CATA and CAA as viable candidates, both misaligned at morpheme-end.

Since the syllabically well-formed candidates tie on ALIGN, violating it, the decision between them occurs in the rest of the hierarchy. Ready to perform the assessment is FILL, which selects the form making least use of empty structure: the monosyllable .CAA., with two empty moras. This outcome is shown in (50):

## (50) Augmentation of /p/ ‘feed’

Candidates	CODA-COND	ALIGN-L	ONSET	ALIGN	FILL
$\text{p} \cdot  p  \text{AA}$				*	**
$\cdot  p  \text{A} \cdot \text{TA}$				*	*** !
$\cdot  p  \text{A} \cdot \text{A}$			* !	*	**
$[\text{A}   p   \cdot]$	* !	* !	*		*
$[\cdot \text{TA}   p   \cdot]$	* !	* !			**
$[\text{A} \cdot   p   \text{A} \cdot]$		* !	*	*	**
$[\cdot \text{TA} \cdot   p   \text{A} \cdot]$		* !		*	***

Here we see, in a concrete instance of the general argument just given, that monoconsonantal /p/ cannot be given a syllabically well-formed bimoraic analysis without violating ALIGN, because *p* must be parsed as an onset. Initial epenthesis is excluded by ALIGN-L. The decision falls to FILL, at the bottom of the constraint hierarchy, which favors the minimally epenthetic *pAA* over excessively empty *pATA*.<sup>40</sup>

What counts as less epenthesis will depend on precisely how FILL is formulated. But all reasonable formulations of FILL give the same result, and we cannot use this evidence to settle a delicate technical point. If FILL measures empty positions without regard to their syllabic role, as reflected by the violation marks in table (50), or if FILL reckons any incomplete syllable as a mark, then *pAA* has fewer than *\*pATA*. If there are separate constraints “FILL-Nucleus/Mora” and “FILL-Onset”, as in Prince and Smolensky (1991a, 1991b, 1993), then *\*pATA* but not *pAA* will violate the latter. Finally, even if we modify our representational assumptions so that epenthetic elements are completely specified in the phonology, and then have FILL measure featural differences between input and output, it is still true that *AA* consists featurally of a single segment, but *ATA* must contain the features of three segments. FILL, then, under any construal, limits augmentation of roots /C/ to a long vowel, because they are nonalignable.

There is, however, a somewhat subtle argument for the character of FILL, based again on augmentation of /CV/ roots. Consider the possibility of **medial** augmentation, here illustrated with the root /t<sup>h</sup>o/, so that the contrast is phonetically apparent:

<sup>40</sup>Black (1991a:202, 1991b:10) proposes that CV roots like /na/ augment as *naTA* rather than *\*naA* because a light-light syllable sequence is prosodically optimal (modifying Prince 1991). But, as Spring (1991:14-15) notes, this account predicts that monoconsonantal roots like /p/ should augment as *\*pATA* rather than *pAA*. Instead, Spring (1990a:161-162; 1992:6-7) observes that the difference between the two modes of augmentation can be related to the limitation of *T*-epenthesis to heteromorphemic sequences. Although Spring’s interpretation of this relation (based on cyclic syllabification and a special restriction on *t* epenthesis) does not translate, her basic insight that the two phenomena are connected is echoed in our analysis.

## (51) Final vs. Medial Augmentation

- a. [ t<sup>h</sup>o. | TA.            ↗ t<sup>h</sup>oTA  
 b. [ t<sup>h</sup>A. To. |            \* t<sup>h</sup>ATo

Both candidates are properly aligned on both edges, so they tie on all relevant constraints. They also are treated equally by all methods of FILL evaluation except for the reckoning of incomplete syllables. In (51b), two syllables are crucially incomplete, whereas in (51a) all incompleteness has been confined to a single syllable. This suggests that at least one sense of FILL must assess whole syllables for empty structure they contain.<sup>41</sup>

In this section we have seen that two essential properties of augmentation follow from previously established aspects of Axininca Campa grammar; no new constraints and no new rankings have been introduced. Roots /CV/ augment to CVTA because of ALIGN and ALIGN-L. Roots /C/ are not end-alignable, and therefore augment *minimally* to CAA.

## 4.3.3 SFX-TO-PRWD: The Source of Augmentation

The constraints ALIGN and ALIGN-L determine the mode and position of augmentation, by demanding a certain kind of relation between prosodic and grammatical structure. The third and final condition on the phenomenon requires, mysteriously, that augmentation take place before C-initial suffixes and before the reduplicative affix. We will find that another constraint of the alignment family is at play, with even more profound consequences for the phonology of the language.

The first step toward this constraint is Spring's proposal that the *Base of reduplication* is a PrWd (Spring 1990a: 140-163; 1990b: 501; 1992; cf. Black 1991b:10). The Prosodic Hierarchy (35) and the principle of Foot Binariness (37) together entail that Prosodic Words are at least two moras long, and this holds without exception in Axininca Campa. Consequently, the PrWd base of reduplication must display augmentation to bimoraicity.

This handles the reduplicative side of the issue, but has nothing to say about the effect of C-initial suffixes, and the corresponding lack of effect of V-initial suffixes. The following examples illustrate this phenomenon:

## (52) Suffixal Effects on Augmentation, from /na/

- |            |                          |
|------------|--------------------------|
| __ +C~     | __ +V~                   |
| naTA-piro~ | na-T-aanc <sup>h</sup> i |
| naTA-wai~  |                          |

Bimoraicity is evoked by C-initial suffixes just as by reduplication. (This observation is due to Payne (1981:145), but has not played a role in subsequent work.)

---

<sup>41</sup>Alternatively, \*t<sup>h</sup>ATo (51b) may be disfavored because epenthesis introduces a discontinuity into the root. If there is a cross-linguistic bias against medial epenthesis, especially in circumstances where there is a choice between medial and peripheral epenthesis, then an appropriate constraint legislating continuity can be devised. Whatever its ranking in Axininca Campa, this constraint would correctly select t<sup>h</sup>oTA (51a) over \*t<sup>h</sup>ATo (51b), since these two candidates tie on all other constraints.

We propose that the apparent phonological restriction is a descriptive artifact. The actual linguistic principle responsible for the observed effects, we assert, places the PrWd Base requirement on *every* suffix, regardless of its segmental make-up. It relates morphological category to prosodic category in the by-now familiar ALIGN-theoretic way:

(53) SFX-TO-PRWD

The Base of suffixation is a Prosodic Word.

By ‘Base’ is meant the phonological material that precedes the suffix, a notion that figures in reduplication theory as well (§5.2). A word structure satisfying this constraint is one in which the left edge of each suffix coincides with the right edge of a Prosodic Word.<sup>42</sup> Equivalently, it is one in which the initial element of the suffix abuts the final element of a PrWd.<sup>43</sup>

Like ALIGN and ALIGN-L, this constraint governs the morphology-prosody interface, demanding a particular relation between grammatically-defined structure — here, the phonological content of the suffix morpheme — and another structure that is defined in purely phonological terms. Properly integrated into the grammar, the constraint SFX-TO-PRWD will guarantee (through its interaction with FILL and with the principles of PrWd-form) that any structures satisfying it will display a Base of suffixation at least two moras in size. Less obviously, the interaction with other constraints will turn out to distinguish successfully between C-initial and V-initial suffixes, in much the same way as ALIGN turned out to distinguish V+V juncture from all others and the augmentation of /C/-roots from that of /CV/-roots.

First, the C-initial suffixes. Here the key assumption is simply that SFX-TO-PRWD dominates FILL, so that the interface constraint can compel epenthesis. The following tableau assesses the chief alternative candidates:

(54) C-initial suffixation of /na/

Candidates	FTBIN	SFX-TO-PRWD	FILL
na piro]		* !	
na] piro	* !		
☞ naTA] piro			**

<sup>42</sup>Thus, with suitable technical development, one might write  $[_{Sfx} = ]_{PrWd}$ . This constraint, then, matches different edges, a possibility not contemplated in the Chen/Selkirk theory of the syntax/prosody interface. Rather, SFX-TO-PRWD has closer affinities with the Inkelas (1989) notion of prosodic subcategorization, though of course it is a general constraint on *all* suffixes, not a lexical feature of any particular suffix.

<sup>43</sup>Some cross-linguistic support for SFX-TO-PRWD is suggested by the analogous Sievers’ Law in Germanic. In Gothic, which shows the pattern most clearly, prevocalic *i* becomes *j* after a monosyllabic, light-syllabled stem but not a longer one: *nas.jis* ‘save’, *ar.jis* ‘plow’ vs. *soo.kjis* ‘seek’, *nam.njis* ‘name’, *miki.liis* ‘glorify’, *glit.mu.njis* ‘glitter’. (Examples from Dresher and Lahiri (1991:264).) This result follows directly if the base of suffixation must be a Prosodic Word, hence minimally bimoraic (modulo final consonant extrametricality). For extensive discussion of this and related phenomena, see Riad (1992).

The sign | marks the leading edge of the suffix, which should, if all goes well, abut the trailing edge of the PrWd, marked by a bracket ]. Of the candidates, only the last contrives to meet the interface constraint while maintaining prosodic well-formedness. The cost is violation of FILL, but this is irrelevant since any attempt to avoid it leads to failure on higher-ranked constraints:

- *\*na|piro]*, parsed without a PrWd Base, violates SFX-TO-PRWD
- *\*[na]|piro* offers a monomoraic PrWd as the Base of suffixation, in fatal violation of FTBIN.

All such candidates fail in the face of the actual output form *na<sup>T</sup>A]*|piro, which violates only the lower-ranked constraint FILL. Before any C-initial suffix, then, a subminimal root will be augmented to bimoraicity.

V-initial suffixes, by contrast, pose very different problems for the constraint system. SFX-TO-PRWD demands the following configuration:

(55) ]|V

There is simply no way to achieve this while maintaining syllabic well-formedness. All SFX-TO-PRWD-satisfying Bases must be V-final, since no PrWd ends on a C; therefore we are looking at *V.]|V*, a most unpromising collocation. Let us examine the fate of /na+aanc<sup>hi</sup>/. The direct assault, simply paralleling the augmentation style before the C-initial suffixes, runs afoul of ONSET:

(56) \*na<sup>T</sup>A].|aan.c<sup>hi</sup>

This candidate successfully suffixes to a PrWd, but the V.V hiatus is not tolerated. This observation establishes that ONSET must dominate SFX-TO-PRWD.

Further epenthesis avoids the ONSET violation but destroys the alignment of the suffix-edge and the PrWd-edge:

(57) \*na<sup>T</sup>A].T|aan.c<sup>hi</sup>

Ill-aligned *na<sup>T</sup>A]T|aanc<sup>hi</sup>* must then face ill-aligned *na<sup>T</sup>|aanc<sup>hi</sup>*. With SFX-TO-PRWD out of the equation, failed by both serious candidates, the decision falls to FILL, which has no care for Prosodic Words. The most faithful candidate, most conservative in epenthesis, is selected: *na<sup>T</sup>aanči*, with no syllabic augmentation.

V-initial suffixes, then, can *never* be properly aligned with a PrWd base while at the same time satisfying the high-ranked constraints on syllable structure. With the ranking ONSET >>SFX-TO-PRWD in effect, the interface constraint SFX-TO-PRWD imposes no requirements on the Base of V-initial suffixation. Epenthesis feels only the force of syllabic conditions, ONSET in particular. This argument is laid out with a set of plausible candidates in tableau (58):

(58) V-initial Suffixation /na+aanc<sup>hi</sup>/

Candidates	ONSET	FTBIN	SFX-TO-PRWD	FILL
a. na]. aanc <sup>hi</sup>	* !	* !		
b. naTA]. aanc <sup>hi</sup>	* !			**
c. na. aanc <sup>hi</sup> ]	* !		*	
d. naTA].T aanc <sup>hi</sup>			*	*** !
e.  na.T aanc <sup>hi</sup> ]			*	*

The candidates (58a, b) are properly aligned, but stumble on syllabic and prosodic well-formedness, enforced through dominant constraints. Example (58c) avoids FBIN and FILL violation, but is neither properly suffix-aligned nor syllabically well-formed. The last two examples (58d, e) consist of satisfactory syllables; both are therefore necessarily ill-aligned at the Base-suffix join; the winner is chosen, as noted, by minimality of FILL-violation.

When the stem is C-final and the suffix V-initial, as in /č<sup>hi</sup>k-aanc<sup>hi</sup>/, similar considerations apply. SFX-TO-PRWD wants to see ]|V, and the *Base* must still be end on a vowel for the usual syllabic reason, regardless of the fact that the *stem* ends on a consonant. Thus, all successful alignments have bad syllables:

## (59) Syllabically-Disharmonic Suffixal Alignments

- a. ~C.]|V  
b. ~.CA.]|V

Form (59a) violates both CODA-COND and ONSET. Form (59b) merely violates ONSET. In addition, though, it violates the stem-relevant constraint ALIGN, because the stem-end is not at the end of a syllable. Dealing with the ONSET problem through further epenthesis terminates any hope of obtaining suffixal alignment:

## (60) ~.C|A.]T|V

This form is neither stem-aligned nor suffix-aligned. This puts it exactly on a par, as far as alignment goes, with the faithful parse:

(61) ~[C||V...]<sub>σ</sub>

The stem ends mid-syllable; and the suffix begins there, far from the edge of any PrWd. Consequently, with all alignment mooted, the decision falls once again to FILL, which selects the simple faithful parse.

The force of this argument is apparent in the following tableau, using the root /č<sup>hi</sup>k/. Only syllabically well-formed candidates are shown.

(62) /č<sup>h</sup>i.k+aanc<sup>h</sup>i/ ‘to cut (infinitive)’

Candidates	ALIGN	SFX-TO-PRWD	FILL
☞ .č <sup>h</sup> i.k     aanc <sup>h</sup> i.]	*	*	
.č <sup>h</sup> i.k   [A.]T   aanc <sup>h</sup> i.	*	*	** !

Examples of this sort are particularly revealing of the way that Optimality Theory differs from other approaches to constraint satisfaction (e.g., Myers 1991, Paradis 1988a, 1988b, Goldsmith 1990, 1991). For some approaches, the fact that the constraint is not phonotactically true would render it grammatically unusable. For others, the conflict with ONSET could set off a pathological chain of events. Enforcement of SFX-TO-PRWD on /na-aanc<sup>h</sup>i/ would trigger augmentation to *naTA.aanc<sup>h</sup>i*. But this form violates ONSET, so it would be subject to further repair, yielding \**naTATA.aanc<sup>h</sup>i*. Once again, the constraint SFX-TO-PRWD is useless. The wrong outcome is a consequence of viewing constraint satisfaction as a step-wise derivational procedure that incrementally approaches total well-formedness by applying rules or repair strategies one after the other. The perspective of Optimality Theory is very different. Inviolability is not a prerequisite to constraint-hood, and satisfying the constraint system is a one-step operation. Given the high rank of ONSET, V-initial suffixes necessarily violate SFX-TO-PRWD. This doesn't mean that they are ungrammatical, only that their fate is decided by other constraints (FILL in particular). In this way, an otherwise inexplicable distinction between V-initial and C-initial suffixes emerges from the interaction of quite general constraints, with all reference to segments sequestered in the syllable structure component.

It is worth noting that there can be no crucial ranking between ALIGN and SFX-TO-PRWD. To see this, recall that the ranking scenario demands a conflict structure like this, where one of *cand*<sub>1</sub> and *cand*<sub>2</sub> is optimal:

(63) Attempt to Rank ALIGN and SFX-TO-PRWD

Candidates	ALIGN	SFX-TO-PRWD
<i>cand</i> <sub>1</sub>	*	
<i>cand</i> <sub>2</sub>		*

But no underlying form can give rise to this configuration. Assume syllabic well-formedness, without which the comparison is pointless. Then only stems ...V can yield stem-aligned forms like *cand*<sub>2</sub>. Only suffixes C... can yield suffix-aligned forms like *cand*<sub>1</sub>. Therefore, the underlying form must be shaped ...V+C.... But the optimal candidate from this will satisfy *both* of the interface constraints, and no conflict arises.

SFX-TO-PRWD also derives augmentation of the Base under reduplication, as in forms like these (further discussed in §5.2 below):

## (64) Reduplicative Augmentation

- a. /na-RED-wai-ak-i/      na<sup>TA</sup>-na<sup>TA</sup>-waiTaki  
 b. /p-RED-wai-ak-i/      p<sup>AA</sup>-p<sup>AA</sup>-waiTaki  
 c. /p-RED-ak-i-na/      p<sup>AA</sup>-p<sup>AA</sup>-Takina      (Spring 1990a:148-9)

Because the reduplicative morpheme is a suffix, the Base of reduplication is subject to SFX-TO-PRWD just like the Base of any other suffix.<sup>44</sup> Suffixed Reduplicants are always consonant-initial, for reasons developed below in §5.2. Thus, reduplicative suffixation will induce augmentation of a subminimal Base just like any other consonant-initial suffix:

## (65) Reduplication of /na/

Candidates	FTBIN	SFX-TO-PRWD	ALIGN	FILL
na.   na.		* !		
na. ]   na.	* !			
na   A. ]   naA.			* !	**
 .na   .TA ]   na.TA.				****

The details of the argument here are identical to that given in the discussion of tableau (54) above. The optimal form obtains prosodic well-formedness (FTBIN) as well as proper alignment at the stem-terminus (ALIGN) and at the Base-suffix juncture (SFX-TO-PRWD), violating only FILL. The other candidates trade violation of FILL for worse infractions, a fatal exchange given its subordinate position in the hierarchy.

One further issue remains: what are the effects of SFX-TO-PRWD on affixation to *longer* stems, two moras or more in length? None are desired, since there is augmentation only of subminimals. And it turns out that there are none. The only relevant environment is before C-initial suffixes, because (as just shown) this is the only environment where SFX-TO-PRWD can be met in an optimal candidate. But a long stem always has (by definition) enough material in it to count as a PrWd on its own, without augmentation. The PrWd condition on the Base of suffixation is satisfied by what's already there underlyingly. When the stem ends in C, there will be epenthesis of A, of course, due to CODA-COND §4.1 and ALIGN (§4.2), but this has nothing to do with any requirements on the size of the Base.

In this section, we have seen that the very particular effect of augmentation of subminimal stems before C-initial suffixes follows from the presence in the grammar of the alignment constraint SFX-TO-PRWD, stated in the most general terms so as to hold of all suffixes, regardless of their

<sup>44</sup>Reduplication of vowel-initial forms presents another twist which is not relevant to SFX-TO-PRWD phenomena; we simply note it for now, and return to it at length in §5.4. When the root is V-initial and short, as it is with forms like /i/ 'precede' or /asi/ 'cover', the reduplicative morpheme RED is treated not as a dependent suffix but as a root, and suffixation is abandoned in favor of compounding, because ONSET is involved. Since RED is not a suffix in this circumstance, SFX-TO-PRWD is not invoked.

segmental content or position in the word. The crucial rankings required to situate the constraint in the hierarchy are two in number:

- ONSET  $\gg$  SFX-TO-PRWD, because suffixal alignment cannot be achieved at the expense of syllabic wellformedness (\*V|.V).

- SFX-TO-PRWD  $\gg$  FILL, because suffix alignment can force augmentation.

#### 4.4 Summary of Prosodic Phonology

Three families of constraints govern the prosodic phonology of Axininca Campa:

##### (66) Constraint Families

- a. Syllable Structure: ONSET, CODA-COND
- b. Faithfulness: PARSE, FILL
- c. Alignment: ALIGN-L, ALIGN, SFX-TO-PRWD

The arguments pursued above set the domination relations that mold these into a grammar. For convenience of reference we tabulate here the entire collection of empirically motivated rankings:

##### (67) New Rankings

Rankings	Effects
PARSE $\gg$ FILL	Epenthesis rather than deletion (4)
ONSET $\gg$ FILL	Epenthesis to provide onset (10)
CODA-COND $\gg$ FILL	Epenthesis to provide nucleus (3)
ALIGN-L $\gg$ ONSET	No epenthesis in stem-initial position <sup>45</sup> (16), (48) Onsetless initial syllables freely allowed
CODA-COND $\gg$ ALIGN	Coda well-formedness not sacrificed to get stem-alignment (25)
ALIGN $\gg$ FILL	Epenthesis not coalescence at V+V juncture (21) No spreading of Place to legitimize C+C clusters (28) Add syllable to /CV/ but mora to /C/, under augmentation (44-50)
ONSET $\gg$ SFX-TO-PRWD	Onset well-formedness not sacrificed to get suffix-alignment (56)
SFX-TO-PRWD $\gg$ FILL	Augment to gain well-formed PrWd (54)

The structure of the ranking system can be rather more perspicuously displayed in a Hasse diagram:

<sup>45</sup>See fn. 28 for discussion of the possibility of non-ranking of these constraints.



into a single syllable, but without a specific constraint against coalescence *per se*. By the same token, it bans spreading of features or feature-geometric nodes across the stem-suffix juncture, which would phonologically legitimize certain C+C clusters; again with no constraint specifically aimed against such spreading. A third consequence is the alignment-preserving augmentation of CV to .CV.TA. rather than to .CVA., contrasting with the FILL-conservative augmentation of nonalignable C to CAA. To the traditional eye, these disparate-appearing facts suggest a cluster of highly particular epenthesis rules, bristling with parochial contextual stipulations. Alignment theory reveals their common source, once again justifying the extreme generality of the Gen/FILL attack on epenthetic phenomena.

SFX-TO-PRWD demands that each suffix stand immediately after the end of a Prosodic Word. When the rest of the grammar is taken in to consideration, this entails that subminimal bare roots are augmented to bimoraicity before suffixes beginning with a consonant, including the reduplicative suffix. There is no mention of subminimality or of bimoraicity — no “minimal word constraint” — a virtue carried over from the classical theory of word minimality in Prosodic Morphology (McCarthy and Prince 1991a,b). Nor is there reference to the *stem*, the *bare root*, or to the *consonant* with which the suffixal morpheme commences. The simple align-theoretic condition relates a morpheme edge to a prosodic category edge, the standard format for such constraints. The curious property “C-initial” enters in because it is only C-initial suffixes that *can* abut a PrWd in optimal forms, given the syllabic grammar of the language. Here again, a set of phenomena that seem to cry out for ad hoc stipulation emerge from the interaction of constraints that very much have the air of plausible candidates for membership in UG.

Essential to the argument is the Optimality-Theoretic notion of ranking and concomitant violability of constraints. ALIGN-L **alone** holds observationally of the language. Not every syllable has an onset, and it is certainly not the case that every morpheme ends where a syllable ends (ALIGN). The relation between SFX-TO-PRWD and the surface is perhaps even more opaque. Interaction means violation, however, and it is only through interaction that the broad conflicting claims of the general can be modulated into the coherent particularities of a single language.



## 5. The Prosodic Morphology of Axininca Campa

### 5.1 Overview

The patterns of verbal reduplication in Axininca Campa are laid out in table (1). Reduplication of the bare root is shown in the first column. In the second column, the effects of prefixation are displayed, using *n-/no-/no-N-* ‘I-FUT’. To avoid cluttering the table, we have not indicated which segments are epenthetic, but we cite the underlying forms of nonobvious roots so that this information can be easily recovered. Tense and other suffixes that follow the reduplicative complex have been omitted. Reduplicative morphology adds the nuance ‘more and more’.

#### (1) Axininca Campa Reduplication

##### a. C-initial Long Roots: $\geq \sigma\sigma$ .

*Total Reduplication of Root, excluding Prefix.*

kawosi– <u>kawosi</u>	<i>noŋ</i> -kawosi– <u>kawosi</u>	‘bathe’ <sup>46</sup>	
t <sup>h</sup> aaŋki–t <sup>h</sup> aaŋki	<i>non</i> -t <sup>h</sup> aaŋki–t <sup>h</sup> aaŋki	‘hurry’	
kint <sup>h</sup> a– <u>kint<sup>h</sup>a</u>	<i>noŋ</i> -kint <sup>h</sup> a– <u>kint<sup>h</sup>a</u>	‘tell’	
č <sup>h</sup> ika– <u>č<sup>h</sup>ika</u>	<i>noñ</i> -č <sup>h</sup> ika– <u>č<sup>h</sup>ika</u>	‘cut’	/č <sup>h</sup> ik/
tasonka– <u>tasonka</u>	<i>non</i> -tasonka– <u>tasonka</u>	‘fan’	/tasonk/

##### b. C-initial Short roots: $\leq \sigma$ .

*Total Reduplication of Stem, including Prefix.*

(i) naa– <u>naa</u>	<i>no</i> -naa– <u>nonaa</u>	‘chew’	
(ii) nata– <u>nata</u>	<i>no</i> -na– <u>nona</u>	‘carry’	/na/
t <sup>h</sup> ota–t <sup>h</sup> ota	<i>non</i> -t <sup>h</sup> o– <u>nont<sup>h</sup>o</u>	‘kiss, suck’	/t <sup>h</sup> o/
paa– <u>paa</u>	<i>no</i> -wa– <u>nowa</u>	‘feed’	/p/

##### c. V-initial Long Roots: $\geq \sigma\sigma\sigma$ .

*Reduplication excludes first syllable.*

osaŋkina– <u>saŋkina</u>	<i>n</i> -osaŋkina– <u>saŋkina</u>	‘write’	
osampi–sampi	<i>n</i> -osampi– <u>sampi</u>	‘ask’	
oiriŋka– <u>riŋka</u>	<i>n</i> -oiriŋka– <u>riŋka</u>	‘lower’/oiriŋk/	
aacika– <u>cika</u>	<i>n</i> -aacika– <u>cika</u>	‘stop’	/aacik/
amina– <u>mina</u>	<i>n</i> -amina– <u>mina</u>	‘look’	/amin/

##### d. V-initial Short roots: $\leq \sigma\sigma$ .

*Total Reduplication of Stem, including first syllable.*

asi   <u>asi</u>	<i>n</i> -asi– <u>nasi</u>	‘cover’	
api   <u>apii</u>	<i>n</i> -apii– <u>napii</u>	‘repeat’	/apii/
ooka   <u>ooka</u>	<i>n</i> -ooka– <u>nooka</u>	‘abandon’	/ook/
aka   <u>aka</u>	<i>n</i> -aka– <u>naka</u>	‘answer’	/ak/

The base of reduplication must be the morphological category *Stem*, formed of prefix plus root, since the entire Stem can reduplicate, prefix and all (1b, d: column 2). Reduplication

<sup>46</sup>This root is *kaawosi* according to Spring (1990a).

is suffixal, as is clear from the non-total cases, where the copy consists of a final substring of the base.

## (2) Reduplicative Suffixation

- a. *osampi*] *sampi*]
- b. *noŋ-kawosi*] *kawosi*]

For short V-initial roots like /*apii*/, shown in (1d), reduplication involves separation of base and copy into distinct Prosodic Words, leading to *api*||*apii*~, where the sign || typographically marks the PrWd edges. This is PrWd compounding, rather than suffixation proper, as is apparent from the stress pattern (*ápi*~ not *api*~) and the occurrence of PrWd-final vowel shortening (v. the Appendix). Elsewhere, reduplication is internal; base and copy belong to the same overall PrWd.

The Axininca reduplicative suffix shows an intriguing variety of forms. It ranges in size from one to at least three syllables in length. It may mimic the base exactly, or it may omit the initial syllable of the base. It may copy a prefix, or it may consist entirely of root material, even when a prefix is available for copy. It may be a PrWd-internal suffix, or base and copy may occupy disjoint PrWd's.

Each of these variations is, however, entirely determined by the structure of the base, as should be clear from the layout of table (1).

- For C-initial roots  $\geq \sigma\sigma$ , the *Root* reduplicates but the prefix does not. (1a).
- For C-initial roots  $\leq \sigma$ , the entire *Stem*, prefix included, is copied too. (1bi, ii). When no prefix is present, and the root is no more than one mora long, the base and copy show augmentation. (1bii).
- V-initial roots  $\geq \sigma\sigma\sigma$  reduplicate everything except their initial syllable, whether they are prefixed or not. They behave like long C-initial roots with an additional, but reduplicationally irrelevant initial syllable. (1c).
- V-initial roots  $\leq \sigma\sigma$  reduplicate both syllables, taking along a prefix when it's part of the first syllable. Here, in contrast to the longer V-initial roots, the initial syllable *is* reduplicated. In the unprefixed forms of this type, the base and copy are in separate Prosodic Words. (1d).

Descriptively there are, then, three factors that completely classify reduplicative form in Axininca Campa:

- presence or absence of a prefix
- root size measured in syllables
- root status as C-initial or V-initial.

Summarized in this way, of course, we have only a set of bald and rather puzzling observations; an intertwining of factors. The theory of Prosodic Morphology, though designed to deal with *invariance* of morphemic shape, must also provide the means to explicate this collection of determinate but highly various patterns. The argument will be that the familiar constraints of Prosodic Morphology provide exactly the desired illumination, when allowed to interact in the manner defined in Optimality Theory. In particular, we will argue that the Axininca patterns emerge from the following reduplication-specific constraints:

## (3) Fundamental Constraints on Reduplication in Axininca Campa

- a. Reduplication is total.
- b. The Reduplicant (the copy) is at least disyllabic.
- c. The Reduplicant is a suffix.
- d. The Reduplicant consists of material drawn from the *root* alone.

These constraints are all well-known from typological and theoretical studies of reduplication, and they fix properties that must be declared for every reduplicative morpheme. They are also all false, on the face of it. Organized into a grammar, however, and integrated with the general phonology of the language, they will generate exactly the reduplicative patterns of the language.

The argument will proceed from the simpler to the more complicated and reduplication-specific interactions. We begin in §5.2 with those forms — the unprefixing roots — that involve only the most general universal properties of reduplication (3a), as they interact with the language-particular phonology of Axininca already established (§4). Next in §5.3 we turn to a restriction on the morphological integrity of the Reduplicant (3d), as well as the quasi-templatic size constraint (3b). Finally, in §5.4 we examine the short V-initial roots, which exhibit the full set of constraints, including one on the morphological status of the Reduplicant (3c). We conclude this section with an overview of the structure of the analysis, focusing on the role and relationships of the various constraints on Reduplicant form (§5.5).

## 5.2 General Properties of Reduplication: Unprefixing Roots

The fundamental mode of reduplication is represented by roots like those in (4), which are consonant-initial, vowel-final, and at least two moras long:<sup>47</sup>

## (4) Long, C-Initial, V-Final Simplex Stems /C~~V/

<i>Base</i>	<i>Reduplication</i>	<i>Gloss</i>
/kawosi/	kawosi- <u>kawosi</u> -waiTaka	‘bathe’
/koma/	koma- <u>koma</u> -waiTaki	‘paddle’
/kint <sup>h</sup> a/	kint <sup>h</sup> a- <u>kint<sup>h</sup>a</u> -waiTaki	‘tell’
/t <sup>h</sup> aan̄ki/	t <sup>h</sup> aan̄ki-t <sup>h</sup> aan̄ki-waiTaki	‘hurry’
/naa/	naa- <u>naa</u> -waiTaki	‘chew’

These examples transparently illustrate the core of the whole system: total root reduplication. The burden of the analysis is to explain exactly how other factors impinge on this simple pattern.

The theory must provide a set of principles yielding total reduplication, which will generalize naturally to instances of partial reduplication. It must also characterize the role of reduplication in the morphology, so as to specify the meaning of reduplicative morphemes and

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<sup>47</sup>For purposes of legibility, we adopt a notation to schematize phonological string-types. The tilde ~ will generally be used as a variable over segments. In citing root patterns, double tildes ~~ will indicate long roots, single tilde ~ short roots. For example, we will write /C~~V/ to refer to *long*, C-initial, V-final roots; /C~C/ will refer to *short* C-initial, C-final roots; and so on. The terms “long” and “short” have a strongly contextualized meaning; we will try to keep it clear in each case. When size doesn’t matter we will use dashes, as in /C—C/, indicating roots beginning and ending in C.

to allow them to be governed by constraints on the morphology/prosody interface like SFX-TO-PRWD.

The first order of formal business is to identify the elements that reduplication theory refers to. We will assume that certain morphemes are marked as *reduplicative* (RED); they lack phonetic content lexically and are supplied with it in the output. They are subject to special constraints that determine the character of the segmental and syllabic material they are expressed by. Such constraints will include familiar templatic restrictions (“is a heavy syllable, foot”, etc.) as well as general principles defining the “copying” relationship. The ‘more and more’ reduplicative of Axininca Campa is such a morpheme: we will often write simply RED for this morpheme, highlighting its reduplicative character, as in the following expressions:

(5) /Root+’more and more’+Continuative+.../

/Root+RED+Continuative+.../

e.g. /kawosi+RED+wai+ak+a/

The morpheme denoted by RED is an element of the *input* or underlying representation, and like all such elements it is carried over into the candidate outputs. To refer to the actual material associated with RED in candidate *output* forms, we will adopt Cari Spring’s apt term *Reduplicant*. The Reduplicant, then, is the exponent of RED, in the same way that e.g. *kawosi* is an exponent of a Root. One key difference between lexically **specified** morphemes and lexically **unspecified** RED comes from the assumption (Consistency of Exponence (§2.3)) that the principles admitting candidate output forms do not permit changes in the exponence of **specified** morphemes: the underlying and surface segmental affiliation of a given morpheme must be identical (v. also §4.2). But because RED is unspecified for intrinsic phonetic content, there are no a priori restrictions on what the Reduplicant can be. Rather, the Reduplicant’s character is fully determined by the system of constraints on prosodic structure and copying. Thus, any linguistic expression whatsoever is a legitimate candidate Reduplicant, suitable for evaluation by the system of constraints. (All but one such candidate will typically turn out be non-optimal, of course, under assessment.) Because the Reduplicant is just the surface exponent of RED, it is necessary in any given candidate analysis to know what the intended exponent of RED is. To make this clear, we have consistently followed the practice, introduced in (1), of underlining the Reduplicant being evaluated in each candidate form.

We also require a characterization of the phonological string that the Reduplicant copies, called the *Base*. The concept of the Base was first introduced in §4.3, as part of the explication of the constraint SFX-TO-PRWD. Recall that SFX-TO-PRWD asserts that the left edge of a suffix morpheme must coincide with the right edge of a Prosodic Word; that is, the *Base* of suffixation is a PrWd. In any output candidate, the Base comprises the phonological material that immediately precedes the exponent of the suffix morpheme. The reduplicative morpheme RED is just another suffix in this respect, demanding PrWd-hood of its base, as shown by augmentation of short reduplicated roots like *naTA-naTA* and other phenomena discussed below. Since the suffix RED has no intrinsic phonetic content, its left edge is exactly the left edge of the Reduplicant, and its right edge is the right edge of the Reduplicant. Thus, the Base and Reduplicant are strictly adjacent, and SFX-TO-PRWD requires that the structure of reduplicated words be [Base]<sub>PrWd</sub>|Reduplicant+~.

The notion Base (abbreviated B) is also essential to stating the copying constraints which characterize the Reduplicant (abbreviated R). We take the fundamental copying constraints to be CONTIGUITY, ANCHORING, and Maximization (MAX), which re-state principles in McCarthy and Prince (1986).

#### (6) CONTIGUITY

R corresponds to a contiguous substring of B.

This is a formulation of the ‘no-skipping’ requirement of McCarthy and Prince (1986:10). To proceed somewhat more exactly, we might identify a correspondence function  $f$  between R and B, which must meet three conditions:

- i. Totality.  $f(r)$  exists for all  $r$  in R.
- ii. Element Copy.  $f(r)=b \Rightarrow [r]=[b]$ , for  $r$  in R,  $b$  in B.
- iii. Element Contiguity.  $r_i \wedge r_j \Rightarrow f(r_i) \wedge f(r_j)$

Totality says that everything in the Reduplicant has a correspondent in the Base. Element Copy says that the correspondent of an element is phonologically identical to it; the Reduplicant consists of material ‘copied’ from the Base. Element Contiguity says that neighbors in R correspond to neighbors in B. The constraint we have called CONTIGUITY then demands the existence of such an  $f:R \rightarrow B$ . Each candidate analysis comes with a correspondence function; correspondence could be portrayed by coindexation or some such device; generally it is clear, however, and will not be notated.

A second constraint places a further structural restriction on the Base-Reduplicant relation:

#### (7) ANCHORING

In R+B, the initial element in R is identical to the initial element in B.

In B+R, the final element in R is identical to the final element in B.

The Reduplicant R and the Base B must share an edge element, initial in prefixing reduplication, final in suffixing reduplication<sup>48</sup> (McCarthy and Prince 1986:94).

The third constraint governs the extent of match between B and R.

#### (8) MAX

$R = B$ .

By MAX, the Reduplicant R is phonologically identical to the Base B (McCarthy and Prince 1986: 105). In other words, reduplication is total.<sup>49</sup>

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<sup>48</sup>As stated, this is nothing more than a forced association between prefixing and initial-substring copying, suffixing and final-substring copying. A more interesting characterization is possible if we define ‘prefix’ as a leftmost substring, suffix as a rightmost substring (as in Prince and Smolensky 1991a). Then we can say that R and  $f(R)$  must, in their respective domains — {B,R}, {B} — both be prefixes, or both be suffixes. Prefixality/suffixality is a property, like various others, on which R and  $f(R)$  must agree.

<sup>49</sup>In terms of the correspondence function  $f$ , one would write  $f(R) = B$ .

All of these constraints have correlates and predecessors in autosegmental theory. The CONTIGUITY Constraint harkens back to the principle of one-to-one association in Clements and Ford (1979), McCarthy (1979a, 1981), and Marantz (1982). ANCHORING is tangentially related to the directionality of association in Clements and Ford (1979) and McCarthy (1979a, 1981) and more directly to Marantz's (1982) dictum that melody-to-template association proceeds from left to right in prefixes, from right to left in suffixes (v. also Yip (1988)). Finally, MAX is a remote descendant of the "Well-formedness Condition" of Goldsmith (1976), with its prohibition on unassociated melodemes.

MAX is categorical in its requirements, but like other such constraints, it has a natural gradient interpretation, based on the extent of divergence from exactitude. Each element in B that has no correspondent in R (and conversely) counts as a violation of the identity requirement. Consequently, MAX will supply a partial ordering of candidate Reduplicants according to how much they differ from an exact match of the Base. A Reduplicant will always be preferred by MAX to the extent that it shares more elements (e.g., segments or syllables) with the Base. This interpretive strategy accords with the general approach to gradience in Optimality Theory — MAX seeks identity between Reduplicant and Base, but minimal violation is always accepted as optimal.

In Axininca, as in many languages, ANCHORING and CONTIGUITY are unviolated, as a survey of the pattern summary (1) in §5.1 shows; and therefore the two constraints are undominated in the constraint hierarchy.<sup>50</sup> In contrast, as we shall find, MAX falls at the bottom of the hierarchy, ranked below all constraints on prosody or on the language-particular form of the Reduplicant. Hence, anything that can limit the force of MAX will do so. Indeed, there is an interesting logical structure to the relationship between MAX and the constraints that dominate it. MAX is entirely general in its applicability: it is relevant to the status of **every** Reduplicant. The other constraints that conflict with it are all specialized, and pertain only to a proper subset of Reduplicants. In this scenario of conflict between the special case and general case, the special case must be dominant if it is to be visibly active. With the opposite ranking, the special-case constraint can have no visible effects; it is rendered irrelevant by the dominance of the general case. This is a point of logic rather than a principle of phonological theory; Prince and Smolensky (1993) prove it under the name of 'Pāṇini's Theorem'. A similar configuration is involved in the 'Elsewhere Condition' (Anderson 1969, Kiparsky 1973a), which is however typically developed as an empirical principle of linguistic theory (see Prince and Smolensky 1993:§7 for discussion).

Violations of MAX and related constraints must be reckoned in terms of phonological elements of some specific type. The well-known *quantitative transfer* phenomenon (Levin 1983, Clements 1985, McCarthy and Prince 1988, Steriade 1988a), in which Base vowel length is copied in the Reduplicant, shows that the Base and Reduplicant cannot always be regarded as strings of **segments**, since the segmental level alone does not encode quantitative oppositions. As Spring (1990a:188) observes, Axininca Campa is a language with quantitative transfer in reduplication (*t<sup>h</sup>aaŋki-t<sup>h</sup>aaŋki-waiTaki*). We shall not aspire to settle the complicated issue of transfer here. Rather, we will make the assumption, sufficient for our purposes, that MAX evaluates candidate Reduplicants as strings of segments together with their prosodic affiliations

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<sup>50</sup>It is proposed in McCarthy and Prince (1986) that (the equivalents of) ANCHORING and CONTIGUITY should be taken as unviolated universals of reduplication. At the very least, it can be acknowledged from the current perspective that they show a tendency toward residence at the top of constraint hierarchies.

(such as moras), though it is clear that this move does not provide a full solution to the larger problem of transfer and non-transfer of quantity and other prosodic structure.

With this background, MAX and related constraints can be applied to long unprefixated forms /C~~V/ like those cited in (4). For the form *kawosi*, MAX imposes a ranking on candidate Reduplicants in which *kawosi* itself stands at the top, ahead of all others, including especially *wosi*, and (ranked below it) *si*, both of which consist of contiguous properly-anchored substrings of the Base that meet the syllabic constraints of the language. The optimal candidate is therefore *kawosi*, which is obviously identical to the input. Unfettered MAX will always yield total reduplication.

Still within the realm of totally-reduplicating Bases C~~V are those whose final vowel is the result of *A*-epenthesis after a root /C——C/. The divergence between the Base, which is V-final, and the root, which is C-final, opens up a variety of new interpretive possibilities, and further principles become crucial. The key datum is that when C-final roots are reduplicated, both the original and the Reduplicant display the epenthetic vowel:

(9) Reduplication of Roots /C——C/

/č <sup>h</sup> ik/	č <sup>h</sup> ik <sub>A</sub> –č <sup>h</sup> ik <sub>A</sub> –waiTaki	‘cut’
/kow/	kow <sub>A</sub> –kow <sub>A</sub> –waiTaki	‘search’
/tasonk/	tasonk <sub>A</sub> –tasonk <sub>A</sub> –waiTaki	‘fan’

SFX-TO-PRWD and ALIGN, it will emerge, play a central role in determining the output form.

To begin the argument, it must be shown that epenthetic forms like *kow<sub>A</sub>–kow<sub>A</sub>* are superior to alternatives in which there is no epenthesis at all. The serious candidates have the following shape:

(10) Nonepenthetic Candidates for Reduplication of /C——C/

/č <sup>h</sup> ik/	*č <sup>h</sup> i.k–i.k~
/kow/	*ko.w–o.w~
/tasonk/	*ta.son.k–a.son.k~

Here the candidate Reduplicants are all properly-anchored substrings of the Base, and all syllabification requirements are satisfiable. (The final consonant of the Reduplicant syllabifies with a following suffixal or epenthetic vowel.) FILL is unchallenged, and in this respect these candidates are superior to the actual, doubly-epenthetic output. MAX is violated, but this is irrelevant, since it will emerge subsequently that FILL >> MAX.<sup>51</sup> Nor do these candidates contravene some as-yet-unnoticed universal constraint, since similar reduplications are regularly found in the Mayan languages, such as Tzeltal (Berlin 1963, Kaufman 1971): *ni.t–i.t–an* ‘push’, *čo.l–o.l–an* ‘make rows’. Nonetheless, forms like \**ta.son.k–a.son.k~* are quite impossible in Axininca Campa.

Having established that there is a non-trivial issue here, we now turn to the details of the confrontation between roots /C——C/ and the Axininca Campa constraint hierarchy. Showing

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<sup>51</sup>The constraints FILL and MAX can’t be brought into direct conflict with each other. The ranking result follows from the transitivity of domination; the argument involves the constraints DISYLL and R<ROOT, examined in §5.3 below.

the optimality of a desired candidate is an enterprise of some moment. It does not suffice to cite and dismiss a few alternatives; *every* alternative must be dealt with, from the infinitude of admissible analyses. Since any string at all may be a Reduplicant, this might appear a tall order. Fortunately, certain general properties of Optimality Theory make the task easier to manage. For one thing, violation of undominated constraints will be fatal so long as any alternative exists which does not incur violation; and in the cases at hand, such alternatives always exist. More generally, minimality of violation will have obvious consequences for most freely-constructed candidates. Pointless violation of FILL through random epenthesis, or pointless violation of MAX through excessive omissions, can never lead to optimality; establishing the futility of many such candidates will not require long chains of reasoning.

Let us examine the behavior of forms based on the root /tasoŋk/. Here as elsewhere we omit discussion of candidates whose hopeless status is clear. In the present case, we do not explicitly remark upon Reduplicants *t, ta, tas, taso, tasoŋ, soŋ, taŋ, kon, mapa, ...* obvious violators of MAX or CONTIGUITY; nor upon forms like *tasoŋkATA, tasoŋkATATA, tasoŋkATATATA, ...*, whose excessive violations of FILL are irredeemable; and so on.

The explanation for the non-optimality of (10), we propose, lies in the prosody/morphology interface constraints SFX-TO-PRWD and ALIGN. In the general morphology of the language, SFX-TO-PRWD has the effect of forcing augmentation of subminimal roots to PrWd size before C-initial suffixes.<sup>52</sup> In the reduplicative morphology, this constraint will have the additional effect of compelling a C-initial Reduplicant, as can be seen in the tableau (11). (We continue with the practice, introduced in §4.2, of indicating the PrWd edge with ] and the relevant morphological boundary with |.)

(11) Role of SFX-TO-PRWD in /tasoŋk-RED-~/

Candidates	SFX-TO-PRWD	FILL	MAX
tasoŋ].k a.sonk~	* !		t
☞ tasoŋ.kA.] tasoŋkA~		**	

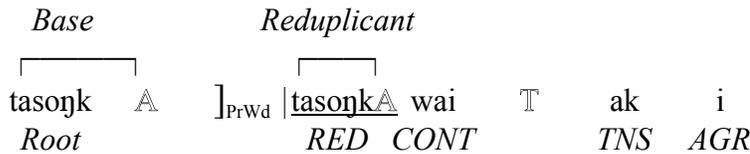
Violation of MAX has been indicated by recording the difference between the Base and the Reduplicant, as befits a constraint with a gradient interpretation.

The application of SFX-TO-PRWD in (11) involves the following considerations. Under SFX-TO-PRWD, reduplicated words must have the structure [Base]|Reduplicant+~. This follows from the formulation of the constraint, given that the left edge of the suffix RED is the left edge of the Reduplicant. The following schema illustrates this:

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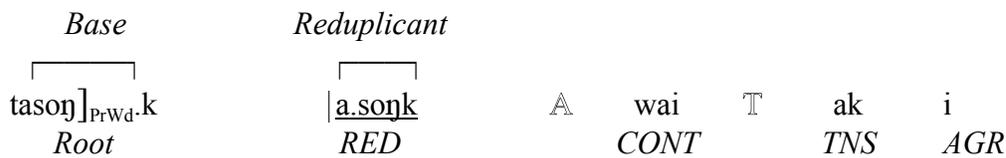
<sup>52</sup>It has no effects with V-initial suffixes because there is no serious candidate available that has the structure ~]|V~, as noted above in §4.3.

## (12) /tasonk-RED-wai-ak-i/ Schematically



In (12) the Base *tasonkA* is a proper Prosodic Word, fully parsed and minimally bimoraic. In contrast, SFX-TO-PRWD is violated by the non-epenthesizing candidate *\*tasonk-asonk*, portrayed in the following diagram:

## (13) /tasonk-RED-wai-ak-i/



Here the Base of reduplication, *tasonk*, is not fully parsable into PrWd. No PrWd can end in a consonant, because of the undominated CODA-COND. In this case, as in the non-reduplicative morphology, the interface constraint SFX-TO-PRWD overrides the demand for faithful rendition of the underlying segmentalism. Thus, the actual output form *tasonkA-tasonkA* violates FILL (twice) in support of the requirement that the reduplicative Base be a PrWd.

Similar remarks can be made with respect to the constraint ALIGN.

## (14) Role of ALIGN in /tasonk-RED~/

	Candidates	ALIGN	FILL	MAX
a.	tasonk.k-a.sonk.k ~	* !		t
b.	tasonkA-ta.sonk.k ~	* !		
c.	tasonkA-ta.sonk.kA. ~		**	

The non-epenthetic Reduplicant *a.sonk.k* in (14a, b) is clearly mis-ALIGNED, since its right edge, shown as usual by the sign |, is not the right edge of a syllable. But the right edge of the epenthesizing Reduplicant *ta.sonk.kA*, and hence of the morpheme RED, does coincide with a syllable boundary, satisfying ALIGN. This is apparent from inspecting (14), and is true even though *tasonkA* ends in a copy of an epenthetic *A*. The status of the final vowel as epenthetic is not crucial for ALIGN, but its morphological function is. In the analysis of interest, the epenthetic vowel is assigned to the Reduplicant — that is, treated as a segmental affiliate of the morpheme RED. (Consistency of Exponence (§2.3) permits this because RED is a phonologically unspecified morpheme.) It follows that RED is properly right-aligned here.

Examples like (14b), with epenthesis in Base but not Reduplicant, have been the focus of particular attention in previous work. Both Base and Reduplicant are followed here by a consonant, making it impossible to syllabify the root-final C without epenthesis. Yet the second

epenthetic *A*, the one in the Reduplicant, owes its existence not to syllabic well-formedness but to its status as part of the Reduplicant (Payne 1981:148, Spring 1990a:109, Black 1991b:11). The relevant test cases involve a V-initial suffix:

(15) Epenthesis in Base and Reduplicant: V-initial Suffixes<sup>53</sup>

/no-č <sup>h</sup> ik-RED-akiri/	-č <sup>h</sup> ikA č <sup>h</sup> ikA-Takiri	‘I cut it and cut it’ Spring (1990a: 109)
	*-č <sup>h</sup> ikA č <sup>h</sup> i.k-a.kiri	
/noŋ-kow-RED-iro/	-kowA kowA-Tiro	‘I will search for it more and more’
	*-kowA ko.w-i.ro	

The feature of interest is the sequence of epenthetic *A* followed by epenthetic *T* at the boundary between the Reduplicant and other suffixes. Syllabic well-formedness constraints could never lead to such double epenthesis, which involves seemingly gratuitous violations of FILL. From the syllabic point of view, there can never be a reason to epenthesize into /~C+V~/; rather the sequence must be syllabified, with complete faithfulness to the input, as ~.CV~ (Prince and Smolensky 1991b; 1993). The starred forms in (15) show exactly this pattern of faithful syllabification: but they are ungrammatical. Consequently, one must look outside of syllable-theory for any constraint forcing the output ~CA.+TV~. In the case at hand, it can only be the principles of Prosodic Morphology — in particular, the morphology/prosody interface constraint ALIGN, as shown in (14) — that are responsible.

Non-optimal (14b) and the starred forms in (15) labor under another defect, besides mis-ALIGNMENT. The Reduplicant is ill-ANCHORED; the rightmost element of the suffixed Reduplicant (*w* in *kow*) is not identical to the rightmost element of the Base (*A* in *kowA*). Here then we have a species of illicit asymmetrical reduplication, and we see that ALIGN and ANCHORING lead to the same result. Their separate contributions can, however, be teased apart under other circumstances, as we show below (29).

In sum, the constraints ALIGN and SFX-TO-PRWD are sufficient to ensure that the otherwise attractive nonepenthetic candidate must lose out. Now, there is no reason to rank either of these constraints above the other. The relevant rankings ALIGN ≫ FILL and SFX-TO-PRWD ≫ FILL are established by phonological considerations independent of reduplication (§4.2).<sup>54</sup> In this way, the analysis captures the Payne/Spring/Black insight that epenthesis in the Reduplicant (as opposed to the Base) is due to its status *qua* Reduplicant, rather than to syllabic well-formedness alone.

The reduplicative behavior of C-initial roots thus follows in a straightforward fashion from general features of Axininca Campa grammar. When the root *is* the Base, as in roots /C~~V/, MAX alone guarantees complete identity between Base and Reduplicant. Among roots /C——C/, there is a significant choice among various expressions of the root, due to the possibility of epenthesis. Because of SFX-TO-PRWD and ALIGN, an epenthetic form must be chosen, assuring the prosodic integrity or *closure* of the Base and the Reduplicant, even when

<sup>53</sup>For morphological reasons, these examples have prefixes, whose reduplicative behavior will be taken up in §5.3 below.

<sup>54</sup>One relevant argument comes from the augmentation of subminimal roots, e.g. /na/. Because SFX-TO-PRWD dominates FILL, augmentation is entailed, violating FILL. Because ALIGN dominates FILL, the augmentation takes the pattern *na/.TA* rather than the more FILL-conservative but mis-ALIGNING *na/A*. Another argument for ALIGN ≫ FILL comes from the impossibility of V+V fusion: *ijkoma-Ti*, \**ijkoma-i*.

otherwise-viable non-epenthetic alternatives exist. In the specific case of asymmetric Base/Reduplicant pairs like *kowA-kow~*, the copying constraint ANCHORING is also applicable, leading to the same result as ALIGN.

We turn now to the long V-initial roots, the analysis of which calls on just one further principle: ONSET, which, in concert with ALIGN-L, demands that all non-PrWd-initial syllables begin with consonants.<sup>55</sup>

Roots /V~/ diverge in one respect from the totality of reduplication seen in the roots /C~/: the onsetless root-initial syllable is never included in the Reduplicant.

(16) Reduplication of Long Roots /V~V/

/osampi/	osampi- <u>sampi</u> -waiTaki	‘ask’
/osaŋkina/	osaŋkina- <u>saŋkina</u> -waiTaki	‘write’

The reason for the failure of maximal identity is not far to seek. Any candidate Reduplicant which exactly mirrored a Base shaped /V~V/ would have to display an impossible hiatus at the Base-Reduplicant frontier: ~V-V~, as in \**osampi-osampi*.

Because ONSET dominates MAX, any total-reduplicating, ONSET-violating candidate must lose its confrontation with an incomplete copy of the Base that allows satisfaction of ONSET. The following tableau shows this for the root /osampi/.

(17) /osampi-RED/

Candidates	ONSET	MAX
.o.sampi-.o.sampi	** !	
☞ .o.sampi- <u>sampi</u>	*	o

The Base *osampi* must violate ONSET, because other options (*[T]osampi* or *|<o>[sampi]*) are foreclosed by higher-ranking ALIGN-L and PARSE (§4.2). But the Reduplicant needn't violate ONSET, and indeed it doesn't, at the price of a mere MAX violation. Failure on low-ranking MAX — that is, partial reduplication — is irrelevant, since the ONSET comparison decides the contest. This evidence shows, of course, that MAX is crucially dominated by ONSET.

ONSET can also be satisfied by epenthesis, as the general phonology of the language makes clear. MAX, we claim, lies at the bottom of the constraint hierarchy, though, so it is dominated by FILL in particular. (This assertion is established in §5.3.) Consequently, FILL-violating epenthesis can never provide a more harmonic candidate than submaximal copying, no matter what else is going on in the grammar. The following tableau should make this clear:

<sup>55</sup>We are indebted to Suzanne Urbanczyk for raising a question about this material that led to a major improvement in the analysis.



the reduplicative Base in *osampi-sampi* is a PrWd, because it is minimally bimoraic and fully syllabified.

Another symmetric pattern, not included in (18), is one in which both Base and Reduplicant are parsed with *initial* epenthesis, again as a kind of “overapplication”.<sup>56</sup> \**Tosampi-Tosampi*. This form violates ALIGN-L, undominated in Axininca Campa and an insuperable barrier to word-initial epenthesis in the language. For convenience, we re-state the constraint here from §4.2 above:

(20) ALIGN-L

$$[_{\text{Stem}} = [_{\text{PrWd}}$$

As can be seen in the following display, the epenthetic C separates the stem-initial segment from the PrWd edge:

(21) [T|osampi-Tosampi

ALIGN-L is violated, fatally, by the first occurrence of T in forms like \**Tosampi-Tosampi*.

In sum, roots /V~~V/ must go with a Reduplicant from which the initial onsetless syllable is missing, a relatively trivial violation of MAX. In this way, the Reduplicant will always satisfy the phonological constraint ONSET, even if the Base does not. C-Epenthesis is used elsewhere in the language to enforce ONSET word-medially, but cannot be so used here: C-epenthetic candidates incur violations of FILL and a variety of higher-ranked constraints bearing on Reduplicant form or on the morphology/prosody interface. Non-copying, violating only low-ranked MAX, provides the optimal solution.

As expected, roots /V~~C/ combine properties of the V-initial class and the C-final class. Like other long V-initial Bases, these roots reduplicate all but the initial syllable:

(22) Reduplication of Long Roots /V~~C/

/amin/	amin <sub>A</sub> - <u>min</u> <sub>A</sub> -waiTaki	‘look’
/oiriŋk/	oiriŋk <sub>A</sub> - <u>riŋk</u> <sub>A</sub> -waiTaki	‘lower’
/aacik/	aacik <sub>A</sub> - <u>cik</u> <sub>A</sub> -waiTaki	‘stop’

Furthermore, as in the C-final roots of (9) above, an epenthetic vowel *A* occurs finally. The epenthetic element must appear in both Base and Reduplicant, due to the force of the interface constraints SFX-TO-PRWD and ALIGN and the copying constraint ANCHORING, as shown in (11)

<sup>56</sup>Though barred in Axininca Campa by undominated ALIGN-L, cases of this type are known in the Paleo-Siberian languages. Kenstowicz (1976:30) argues that Koryak *ʔalaʔal* from /al/ ‘summer’ displays overapplication of ʔ-prothesis, since otherwise *ʔalal* would be expected.

Examples of this type in the closely related language Chukchee (Bogoraz 1922:689) have been interpreted very differently in the literature (Kiparsky 1986:179-180; Steriade 1988a:82). The difference may stem not from a real property of Chukchee but from Bogoraz’s practice of never writing ʔ in onset position. Bogoraz follows the same practice in citing Koryak examples, though Zhukova (1972:24, 42-43; 1980:16, 34) makes it clear that Koryak ʔ is authentically present. Militating against this is Skorik’s (1961) claim that ʔ and Ø contrast in Chukchee. (Thanks to Jaye Padgett for supplying the information from Skorik.)

and (14). Reduplication of stems /V~~C/ violates both MAX, with loss of the initial root syllable in the Reduplicant, and FILL, with the parallel double epenthesis.

This pattern is maintained in the face of a superficially more attractive possibility made available by the presence of the initial vowel: total reduplication, which satisfies both MAX and FILL.

(23) Impossible Total Reduplication of /V~~C/

/amin/	*a.mi.n- <u>a.mi.n</u> ~
/oiriŋk/	*oi.riŋ.k- <u>oi.riŋ.k</u> ~
/aacik/	*aa.ci.k- <u>aa.ci.k</u> ~

Here the Reduplicant-initial vowel is syllabified with the Base-final consonant. (The final consonant of the Reduplicant would syllabify with a following suffixal or epenthetic vowel.) The consequences of ONSET for medial syllables are avoided here by simply not positing a final epenthetic *A* after the root. This is, after all, the pattern with ordinary V-initial suffixes: recall simple *č<sup>h</sup>i.kaan.č<sup>h</sup>i* from /č<sup>h</sup>ik+aanc<sup>h</sup>i/.

But the actual parallel is with reduplication of roots /C——C/, which also reject nonepenthetic solutions to parsing the final C, as demonstrated in (11)-(14) above.

(24) Parallel Between /V~~C/ and /C——C/

/V~~C/	/oiriŋk/	*oi.riŋ.]k  <u>oi.riŋ.k</u> ~	vs.	oi.riŋ.kA.]  <u>riŋ.kA</u>
/C——C/	/tasoŋk/	*ta.soŋ.]k  <u>a.soŋ.k</u> ~	vs.	ta.soŋ.kA.]  <u>ta.soŋ.kA</u>

Total reduplication of /V~~C/, exactly like subtotal reduplication of /C——C/, must violate the constraints SFX-TO-PRWD and ALIGN. But both of these interface constraints dominate FILL, so epenthesis is forced instead, yielding the actual output form *oiriŋkA-riŋkA*, which satisfies both constraints. Here again the interface constraints entail that a C-initial Reduplicant is superior.

The following tableau displays this failure of total reduplication.

(25) Failure of Totality in /oiriŋk-RED-~/

Candidates	ALIGN	SFX-TO-PRWD	FILL	MAX
oiriŋ].k- <u>oi.riŋ.k</u> ~	* !	* !		
☞ oiriŋ.kA.]- <u>riŋ.kA</u> ~			**	oi

In a nonepenthetic candidate like \**oiriŋk-oiriŋk*~, the Base of reduplication *oiriŋk* is not a PrWd, because no PrWd can end in a consonant, due to undominated CODA-COND. (We don't even bother to show ill-syllabified candidates.) Furthermore, the Reduplicant ends amid a syllable, violating ALIGN. The entries in the tableau are annotated to show the relevant structural distinctions.

This example once again illustrates “the strictness of strict domination” (Prince and Smolensky 1993). The optimal form grossly violates two constraints (FILL and MAX) which the

rejected alternative satisfies completely; yet the dominant violations are sufficient to dismiss the candidate with total reduplication.

As with other V-initial roots, there are also a number of plausible candidates that involve positing additional consonantal material to ensure onsets. As before, the additional FILL violations incurred are sufficient to guarantee that none of these forms can appear in the output.

(26) Failure of C-epenthetic Solutions to /V~~C/ Reduplication

	Candidates	FILL	MAX
a.	oiriŋ.kA.-riŋkA	**	oi
b.	oiriŋ.kA.T-oiriŋkA	***	T
c.	oiriŋ.kA.-ToiriŋkA	***	T
d.	ToiriŋkA-ToiriŋkA	****	
e.	oiriŋkAT-oiriŋkAT	****	

Like the comparable epenthetic forms in (18), these will all violate higher-ranked constraints as well as FILL. In particular, the Base/Reduplicant asymmetries in (26b,c) run afoul of basic reduplication theory: they incur violations of ANCHORING when final substrings of the Base and the Reduplicant do not match (26b), and of CONTIGUITY when the Reduplicant contains elements not in the Base (26c). The symmetrical patterns (26d,e) are ruled out by the interface constraints: they violate ALIGN-L where stem-initial epenthesis is essayed (26d), and SFX-TO-PRWD where the Base is consonant-final and the reduplicant is vowel-initial (26e).

The interface constraints SFX-TO-PRWD and ALIGN also play a decisive role in the reduplication of short C-initial roots, this time entirely parallel to their role in the nonreduplicative morphology, where they control the augmentation of short roots before all C-initial suffixes (§4.3).

(27) Reduplication of Short C-Initial Roots /C~/

/na/	naTA-naTA-waiTaki	‘carry’
/t <sup>h</sup> o/	t <sup>h</sup> oTA-t <sup>h</sup> oTA-waiTaki	‘kiss, suck’
/p/	pAA-pAA-waiTaki	‘feed’ (Spring 1990a:148-9; 1992)
	pAA-pAA-Takina	

Subminimal C-initial roots — /CV/ or /C/ — are augmented to bimoraicity when unprefix and reduplicated. The last example crucially shows that augmentation of the Base occurs even when the suffix following the Reduplicant is vowel-initial. Since vowel-initial suffixes do not lead to successful enforcement of SFX-TO-PRWD (§4.3), this example certifies that the reduplicative suffix RED is the true source of augmentation here.

Because the Reduplicant is a suffix, the constraint SFX-TO-PRWD requires its Base to be a PrWd. A PrWd always contains a foot (35), and the constraint FTBIN has the consequence that any foot must be at least bimoraic. Augmentation is the only manner of parsing the input that allows these constraints to be satisfied. The FILL violations incurred by augmentation are low-

ranking, and do not influence the calculation of optimality. Several of the more harmonic candidates are collected in the following tableau to illustrate this argument:

(28) /na-RED/

Candidates	FTBIN	ALIGN	SFX-TO-PRWD	FILL
a. na  <u>na</u>			* !	
b. na  <u>na</u>	* !			
c. $\text{☞}$ na .TA]  <u>naTA</u>				****
d. na  <u>A.</u> ]  <u>naA</u>		* !		**

The candidates are displayed with relevant structure notated:

- \*na|na violates SFX-TO-PRWD, since the Base *na* is not a PrWd. (28a).
- \*[na]|na violates FTBIN, since [na]<sub>PrWd</sub> is too small. (28b).
- $\text{☞}$  [naTA]|naTA violates only FILL, ranked below SFX-TO-PRWD and FTBIN. (28c).

The other plausible augmentation pattern, *na* → *naA*, shown in candidate (d), violates ALIGN, since the root-edge does not coincide with a syllable-edge, as discussed above in §4.2. Similarly, ALIGN-L rules out prothetic augmentation \**TAna*.

The parallel augmentation in Base and Reduplicant confirms what we have assumed throughout: that ANCHORING is undominated. The augmentation of the root /na/ is imposed on it by the reduplicative suffix, via the constraint SFX-TO-PRWD. But, because of ANCHORING, this augmentation must be exactly mimicked in the Reduplicant, compelling violation of FILL:

(29) ANCHORING >> FILL, from *naTA-naTA*

Candidates	ANCHORING	FILL
$\text{☞}$ naTA- <u>naTA</u>		****
naTA- <u>na</u>	* !	**

The form \**naTA-na* is ill-ANCHORED; the rightmost element of Base and Reduplicant are not identical. No other constraint (except DISYLL (§5.3), irrelevant because it is ranked below FILL) distinguishes these two candidates, thereby certifying the validity of the argument.

A striking feature of this example is that augmentation is both *triggered* by the Reduplicant and *copied* by it. The Reduplicant itself compels augmentation of its Base, via SFX-TO-PRWD. Thus, the epenthetic syllable *TA* in *naTA-naTA* is a response to FTBIN. *The second epenthetic syllable TA merely copies the first.* This, then, is a species of “overapplication” — see among others Wilbur (1974), Marantz (1982), Carrier-Duncan (1984), Odden and Odden (1985), Kiparsky (1986), and Mester (1986).

In terms of a serial conception of grammar, this interpretation makes little sense. How can the Reduplicant both trigger augmentation and copy it? Under serialism, **either** reduplication (qua rule) **or** augmentation (qua rule) must apply first. If augmentation is first, then at the time of its application there is no triggering environment present — no consonant-initial suffix — and epenthesis can't apply at all. If reduplication is first, then there can be no epenthetic material to copy. If augmentation applies cyclically, or if rules apply serially but freely, so augmentation can both precede and follow reduplication, the problem is the same, since the context for augmentation is not created until reduplication has applied. These failed derivational paths are sketched here:

(30) Serial Derivational Attempts

a. Augmentation precedes Reduplication

$\sim\text{na}+\text{RED}+\sim \rightarrow \text{No Augmentation} \rightarrow * \sim\text{na} \underline{\text{na}} \sim$

b. Reduplication precedes Augmentation

$\sim\text{na}+\text{RED}+\sim \rightarrow \sim\text{na} \underline{\text{na}} \sim \rightarrow * \sim\text{na} \underline{\text{na}} \text{na} \text{iro}$

c. Cyclic or Free Augmentation

$\sim\text{na}+\text{RED}+\sim \rightarrow \text{No Augmentation} \rightarrow \sim\text{na} \underline{\text{na}} \sim \rightarrow * \sim\text{na} \underline{\text{na}} \text{na} \sim$

But this pattern, a stumbling block to serialism, is fully expected under Optimality Theory. The various candidate forms submitted to the constraint hierarchy are phonologically complete output representations, not the intermediate representations of serial approaches. Thus, the constraints on prosodic structure, the prosody/morphology interface, and on the Base-Reduplicant relation are evaluated in parallel over the full structure. (For similar cases, see Prince and Smolensky 1993: §7.) Solutions to this problem in serialist terms are necessarily *ad hoc*, calling on some complex decomposition of the reduplication operation: for example, the reduplicative *affix* is added, augmentation applies, and only then does reduplicative melody copying and association take place. (Even this solution fails to capture the generalization that the Reduplicant triggers augmentation because it is a C-initial suffix — cf. §4.3.) Under the parallel constraint-satisfaction of Optimality Theory, in contrast, the result could not be any different: a Reduplicant must be true to the Base it sees, and it does not matter whether the Base's phonological properties are underlying or derived. Departures from this requirement are only possible when parallelism itself is subverted, as it would be if reduplication occurred at one level and epenthesis occurred at another, later level.

\* \* \*

In this discussion, we have explored two basic aspects of totality in Axininca Campa reduplication. On the one hand, the high-ranking phonological constraint ONSET compels less-than-full reduplication in V-initial roots, promoting submaximal C-initial candidates. On the other hand, the interface constraints SFX-TO-PRWD and ALIGN, in concert with CODA-COND, force V-epenthesis upon C-final roots.

The potential for additional complexity is supplied by availability of C-epenthetic solutions to requirements of ONSET. Although the position of FILL in Axininca Campa grammar is such as to entail the failure of all such candidates, we found higher-ranked constraints at work as well. The universally high-ranked reduplicative constraints ANCHORING and CONTIGUITY exclude asymmetric C-epenthesis in Base and Reduplicant. Symmetric epenthesis is ruled out by the Axininca interface constraints SFX-TO-PRWD and ALIGN. Together, these ensure that submaximal copying for V-initial roots is the optimal formal response to ONSET.

Like other suffixes, the Reduplicant demands that its Base be a PrWd, satisfied by augmentation of /CV/ roots. The principles of reduplicative copying, ANCHORING in particular, entail that the augmentation is echoed in the Reduplicant.

The phonology involved has been exactly that of the language at large. The relevant reduplication theory has involved three constraints — CONTIGUITY, ANCHORING, and MAX, all well-founded universally and undoubtedly present in every reduplicative system. The interesting patterning was obtained by one move: subordinating MAX in the constraint hierarchy. With this, the behavior of all unprefixing roots that participate in suffixing reduplication has been explicated.

### 5.3 Morphological Integrity and Phonological Size: Prefixed Stems

The reduplicative behavior of prefixed verbs reveals the effects of two new factors: a constraint on the morphological integrity of the Reduplicant ( $R \leq \text{ROOT}$ ) and another governing its size (DISYLL).

When long C-initial roots /C~/ are prefixed, the prefix is not included in the Reduplicant:

#### (31) Long C-Initial Prefixed Stems /C~/

/noŋ-kawosi/	noŋ-kawosi- <u>kawosi</u> -waiČa	‘bathe’
/noŋ-koma/	noŋ-koma- <u>koma</u> -waiTi	‘paddle’
/noŋ-kint <sup>h</sup> a/	noŋ-kint <sup>h</sup> a- <u>kint<sup>h</sup>a</u> -waiTi	‘tell’
/non-t <sup>h</sup> aaŋki/	non-t <sup>h</sup> aaŋki- <u>t<sup>h</sup>aaŋki</u> -waiTi	‘hurry’
/non-tasonk/	non-tasonk <sub>A</sub> - <u>tasonk<sub>A</sub></u> -waiTi	‘fan’

Prefixes are carried along in reduplication under some conditions, as shown in forms like *nonaa-n<sub>A</sub>aa* (38), implying that the prefix must be included within the reduplicative Base. We also know that Prefix+Root is subject to special allomorphy (§3), indicating that the prefix is part of a unit *Stem* that excludes all suffixes, including RED. Therefore, the absence of the prefix from the Reduplicant, as in (31), marks an unexpected divergence from totality of reduplication.

MAX requires that the Base reduplicate exactly, subject only to the demands of dominant constraints. Thus far, we have seen ONSET, a purely phonological constraint, impinging on MAX. A specific condition on the *morphological* integrity of the reduplicant is evidently at play in (31):

#### (32) $R \leq \text{ROOT}$

The Reduplicant contains only the root.

The Reduplicant, by this, cannot contain any phonological elements other than those corresponding to root elements. In terms of the correspondence function *f*, we would say that  $f(R)$  must belong entirely to the exponent of the morphological category *root*.<sup>57</sup>  $R \leq \text{ROOT}$  has an

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<sup>57</sup>One might also contemplate demanding that the morphological category *root* be recognizable within a Reduplicant, so that  $R \leq \text{ROOT}$  would be phrased to make direct reference to the morphological status of the Reduplicant. That is, the elements of the Reduplicant, though they are only copies of the root rather than the root itself, must still partake of root-hood to the extent required to enforce  $R \leq \text{ROOT}$  successfully. This seems difficult

abstract connection with two other proposals for dealing with similar phenomena, Mutaka and Hyman's (1990:83) general *Morpheme Integrity Constraint* and Crowhurst's (1992) specific constraint/repair system that disposes of suffixal vowels in Spanish diminutives.<sup>58</sup>

This constraint is more specific than MAX and conflicts with it, so it must be ranked higher, since otherwise it would not be visibly active, by Pānini's Theorem. As the following tableau indicates, the optimal Reduplicant must consist of the whole Base, as required by MAX, minus the prefix, in conformity with the dominant constraint  $R \leq \text{ROOT}$ :

(33) /noŋ-kawosi-RED/

Candidates	$R \leq \text{ROOT}$	MAX
noŋ-kawosi- <u>noŋkawosi</u>	* !	
noŋ-kawosi- <u>kawosi</u>		noŋ

With MAX subordinate,  $R \leq \text{ROOT}$  characterizes pure root reduplication in the absence of phonological constraints. The reversed ranking also has a natural linguistic interpretation, in which the lower-ranked constraint  $R \leq \text{ROOT}$  is completely irrelevant, so that dominant MAX enforces total Base reduplication.<sup>59</sup>

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of interpretation, given that the Reduplicant must belong to the category *suffix*. By contrast, when the Reduplicant, under duress, heads an independent PrWd, in cases discussed in §5.4 below, it is more reasonable to attribute to it membership — indeed, full membership — in the category *root*.

Another possibility is to see the prohibition on prefixes in the Reduplicant as a consequence of the constraint EDGEMOSTNESS (v. §2, §7, and Prince and Smolensky 1991b, 1993), which limits prefixes to initial position. Then \*noŋ-kawosi-noŋ-kawosi- is ill-formed because the inner prefix is in an illicit locus. This, of course, assumes that noŋ is still analyzed morphologically as a prefix even when it is part of the Reduplicant, raising the same issues as the just-rejected interpretation of  $R \leq \text{ROOT}$ .

<sup>58</sup>From  $R \leq \text{ROOT}$ , ANCHORING, and the requirement (v. §5.4) that the Reduplicant be suffixed, we can derive the fact that the reduplicative suffix of Axininca must *immediately* follow the root, with no other suffixes intervening. Consider what happens if the Reduplicant follows the suffix -wai. If the suffix is copied, then  $R \leq \text{ROOT}$  is violated: \*kawosi-wai-kawosiwai. If the suffix is not copied, then undominated ANCHORING is violated: \*kawosi-wai-kawosi.

<sup>59</sup>Free variation may be a consequence of indeterminate constraint ranking (v. Hung 1992 for another example of this). Just such a case involving the constraints  $R \leq \text{ROOT}$  and MAX is suggested by the differences between Payne's (1981) data and the "Axininca 2" dialect forms elicited by Payne and Spring from a consultant in 1989. In Axininca 2, according to Spring (1990a: 118, 123), the prefix is optionally reduplicated even when the root is disyllabic or longer:

no-koma- <u>nokoma</u> -waici	no-koma- <u>koma</u> -waici	'I continued to paddle more and more'
no-kiŋkit <sup>h</sup> a- <u>nokiŋkit<sup>h</sup>a</u> -waici	no-kiŋkit <sup>h</sup> a- <u>kiŋkit<sup>h</sup>a</u> -waici	'I continued to tell more and more'
n-osampi- <u>nosampi</u> -waiciri	n-osampi- <u>sampi</u> -waiciri	'I continued to ask her/it more & more'

Optional prefix reduplication shows that the ranking between MAX and  $R \leq \text{ROOT}$  is indeterminate in the grammar of Axininca 2.

Interesting as it is, we do not feature this result more prominently because there are various unresolved issues in the Axininca 2 data. According to Spring (1990a: 115), the consultant initially "was hesitant to reduplicate verbs, and refused to reduplicate any form that was not exactly two syllables". During elicitation, another option emerged, involving reduplicating only the first or last two syllables of polysyllabic bases (Spring 1990a: 130, 133). And at the end of the elicitation session (Spring 1990a: 147n.), onsetless initial syllables of polysyllabic bases were reduplicated (cf. §5.2 above).

$R \leq \text{ROOT}$  bars epenthetic elements from the Reduplicant, since epenthetic elements are, by their very nature, not part of any root. (Gen is not free to posit changes in the phonological make-up of specified morphemes, like the root, because of Consistency of Exponence (§2.3). This characteristic of Gen is essential to the alignment constraints (§4.2).) Nonetheless, epenthetic *A* and *T* are common in Reduplicants, and forms that eschew epenthetic elements are often non-optimal, even though they obey  $R \leq \text{ROOT}$ . Typical examples of a sort discussed in §5.2 are given here:

- (34) *naTA-naTA~*                    \**naTA-na~*  
*kowA-kowA-Tiro*                \**kowA-kow~*

The explanation for this pattern lies in the relatively low ranking of  $R \leq \text{ROOT}$  versus the high ranking of the constraints responsible for the appearance of epenthetic segments in the Reduplicant. Epenthetic segments in the Base respond to the requirements of high-ranking constraints like FTBIN, CODA-COND, and SFX-TO-PRWD. These same epenthetic segments must be reflected in the Reduplicant because of ANCHORING (§5.2). Low-ranking  $R \leq \text{ROOT}$  cannot redeem violations of these high-ranking constraints, as the contrast between (a) and (b) shows in the following tableau:

- (35) Epenthetic Elements in Reduplicant /noŋ-kow-RED~/

Candidates	ANCHORING	$R \leq \text{ROOT}$
a.  noŋ-kowA-kowA~		*
b. noŋ-kowA-kow~	* !	
c. noŋ-kowA-nonkowA~		** !

This establishes that ANCHORING conflicts with and therefore crucially dominates  $R \leq \text{ROOT}$ . Now, because of its position in the ranking,  $R \leq \text{ROOT}$  will not succeed in barring all epenthetic segments from the Reduplicant, but it could in principle be responsible for barring *initial* epenthetic segments from R, since these do not fall under the sway of ANCHORING. But because they would have to be paralleled in the base, by CONTIGUITY, initial epenthesis would be excluded in any case by another undominated constraint of Axininca Campa, ALIGN-L (20). Therefore the visible effects of  $R \leq \text{ROOT}$  are limited to prefixes, which is where they are actually observed.

The comparison between (a) and (c) in tableau (35) reveals another truth about  $R \leq \text{ROOT}$ : like MAX, it is categorical in its requirements, but has a natural gradient interpretation, based on the extent of the non-root material copied. Each element in the Reduplicant that is not part of the root constitutes a violation of  $R \leq \text{ROOT}$ , and each such violation can be reckoned separately. In accordance with general principles of Optimality Theory, the minimal violation of  $R \leq \text{ROOT}$  will be preferred. Thus, as shown, *noŋ-kowA-kowA~*, which violates  $R \leq \text{ROOT}$  in just one locus, is

selected over (MAX-imizing) *\*noŋ-kowA-nɔŋkowA*, which violates it twice (at least, depending on how the violations are reckoned).<sup>60</sup>

From these simplest cases we turn now to more complex ones. The prefixed forms of V-initial roots copy neither the prefix nor the root-initial syllable, as the following examples show:

(36) Long V-initial Prefixed Stems /V~/

/n-osampi/	n-osampi- <u>sampi</u> -waiTi	‘ask’
/n-osankina/	n-osankina- <u>sankina</u> -waiTi	‘write’

Just as with *unprefixed* /V~/ stems (18), the constraint ONSET excludes the principal competing candidate, total *root* reduplication. Total *Base* reduplication is ruled out by  $R \leq \text{ROOT}$ . As the tableau shows, the actual output form violates only low-ranking MAX, just like unprefixed *osampi-sampi*:

(37) /n-osampi-RED/

Candidates	ONSET	$R \leq \text{ROOT}$	MAX
n-osampi- <u>nosampi</u>		* !	
n-osampi- <u>.osampi</u>	* !		n
☞ n-osampi- <u>sampi</u>			no

This argument depends only on rankings already established, which place each of ONSET and  $R \leq \text{ROOT}$  above MAX. Only the lowest-ranking constraint MAX is violated in the actual output form *n-osampi-sampi*. As in (18), any candidates which deal with ONSET via C-epenthesis will necessarily contravene FILL and the higher-ranking constraints CONTIGUITY and SFX-TO-PRWD, as in *\*n-osampi-Tosampi* or *\*n-osampiT-osampiT*.

The reduplication-specific constraints invoked to this point have been purely morphological in character, including MAX and  $R \leq \text{ROOT}$ . There is, however, one important phonological constraint on reduplication in Axinca Campa, evidenced by the behavior of short C-initial roots /C~/:

(38) Short C-Initial Prefixed Stems /C~/

/no-w/ <sup>61</sup>	no-wA- <u>nowA</u> -waiTi	‘feed’ (Spring 1990a:148-9; 1992)
/no-na/	no-na- <u>nona</u> -waiTi	‘carry’
/non-t <sup>h</sup> o/	non-t <sup>h</sup> o- <u>nont<sup>h</sup>o</u> -waiTi	‘kiss, suck’
/no-naa/	no-naa- <u>nonaa</u> -waiTi	‘chew’

<sup>60</sup>The gradient interpretation of  $R \leq \text{ROOT}$  is clearly a sensible one. Consider a hypothetical language like Axinca Campa but with multiple prefixes. Dominant DISYLL (v. infra) forces prefix reduplication with monosyllabic roots. If  $R \leq \text{ROOT}$  were interpreted purely categorically, then all prefixes would be copied if one were, because MAX would be the determining constraint. But if  $R \leq \text{ROOT}$  were interpreted gradiently, then only as much prefix material would be copied as need to satisfy DISYLL. Surely the latter circumstance is the more plausible one.

<sup>61</sup>The Stem /no-w/ is from /no-o-p/, lenited and reduced in the Prefix-level phonology.

Here we find reduplication of the agreement prefix together with the root. Prefixal reduplication occurs only when the Base, less the prefix, is monosyllabic; the single remaining syllable can, however, be either monomoraic (*wA*, *na*, *t<sup>h</sup>o*) or bimoraic (*naa*).

That prefixes can reduplicate at all follows from our conclusions about the level organization of Axininca Campa. This mere fact also shows that  $R \leq \text{ROOT}$  is violated and therefore dominated. The dominating constraint states a phonological condition that rules out patterns such as these:

(39) Illicit Monosyllabic Reduplicants

- \*no-wA-wA
- \*no-na-na
- \*non-t<sup>h</sup>o-t<sup>h</sup>o
- \*no-naa-naa

We propose that the constraint DISYLL imposes a prosodic size limitation on the Reduplicant.

(40) DISYLL (Informal)

The Reduplicant is minimally disyllabic.

The constraint DISYLL must obviously dominate  $R \leq \text{ROOT}$  in the hierarchy, to resolve the conflict in its own favor:

(41) /no-naa-RED/

Candidates	DISYLL	$R \leq \text{ROOT}$	MAX
no-naa- <u>nonaa</u>		*	
no-naa- <u>naa</u>	* !		no

Bases that are already disyllabic or longer modulo prefixal material will meet DISYLL, so this constraint can have no effect on their reduplicative behavior. Then  $R \leq \text{ROOT}$  will apply to them with full force.

(42) /noŋ-kawosi-RED/

Candidates	DISYLL	$R \leq \text{ROOT}$	MAX
noŋ-kawosi- <u>kawosi</u>			noŋ
noŋ-kawosi- <u>noŋkawosi</u>		* !	

By virtue of dominating  $R \leq \text{ROOT}$ , which itself dominates MAX, DISYLL has the effect of forcing prefixal reduplication only with monosyllabic (or shorter) roots.

DISYLL does not eliminate all monosyllabic Reduplicants, however, although it could do so, in principle. With FILL in subordinate position in the grammar, there is in fact another way

that bisyllabicity could be achieved: epenthesis. We know that additional material above and beyond root-contents can be posited to ensure the PrWd-hood of suffixed-to Bases, as in these examples:

(43) Epenthesis up to PrWd

- a. /na/ na<sup>TA</sup> ] |wai~  
 b. /p/ p<sup>AA</sup> ] |wai~

From §4.2, we have this pattern as a consequence of the rankings SFX-TO-PRWD ≫ FILL and ALIGN ≫ FILL. The interface constraints compel and shape the form of the FILL violations.

But nothing like this shows up in connection with the demand for Reduplicant disyllabicity. Here instead we find that, so long as the interface constraints are satisfied, a faithfully-parsed monosyllable can be optimal:

(44) Monosyllabicity of Reduplicant

- /naa/            naa-naa  
                   \*naa<sup>TA</sup>-naa<sup>TA</sup>

Reduplicative suffixation is to a PrWd base, satisfactorily bimoraic; epenthesis is not admissible to gain disyllabicity. These facts provide us with crucial evidence that FILL ≫ DISYLL.

(45) FILL ≫ DISYLL Ranking Argument

Candidates	FILL	DISYLL
☞ naa- <u>naa</u>		*
naa <sup>TA</sup> - <u>naa</u> <sup>TA</sup>	* ! ***	

The disyllabic form here violates **no other constraint** than FILL, so only FILL can be responsible for its nonoptimality. This ensures the soundness of the ranking argument based on these facts.

The rankings achieved so far give us these results:

- With FILL ≫ DISYLL, epenthesis can never be called on to yield disyllabicity of Reduplicants. Violation of FILL will be fatal in these circumstances, regardless of any salutary effect on DISYLL.
- With DISYLL ≫ R≤ROOT, prefixal material can be forced into the Reduplicant, in violation of R≤ROOT, to attain disyllabicity.

This means that, from root /naa/, for example, we must have *naa-naa* but *no-naa-nonaa*. This example illustrates a valuable property of Optimality Theory: although the candidate set is far flung in its membership and loose in requirements for admission, the formal relation of constraint domination is capable of exerting a very fine-grained control over patterns of phonological parsing. Without specific ‘repair strategies’ (v. Singh 1987, Paradis 1988a, 1988b) and with no way of tying repair strategies to other rules or morphological processes, the theory relies only on the most general principles of what a linguistic representation can be to generate a candidate set, and on the specific device of constraint domination to evaluate it. Yet quite

subtle restrictions emerge from the interactions within the constraint hierarchy.

With these rankings established, we are finally in a position to validate the claim that FILL dominates MAX, as promised in §5.2. We need only remember that  $R \leq \text{ROOT} \gg \text{MAX}$  to complete the argument from transitivity of domination, putting together all the rankings just noted:

(46) Ranking Chain from FILL to MAX

FILL  $\gg$  DISYLL  $\gg$   $R \leq \text{ROOT}$   $\gg$  MAX

Having clarified its position in the grammar, let us now turn to consider in more detail the character of the constraint DISYLL. Though DISYLL resembles the templates of classical Prosodic Morphology, it cannot be identified with a standard template — a single prosodic category. Disyllabicity is not an absolute requirement of shape-invariance, like familiar templates, but only a lower bound, since trisyllabic reduplicants are impeccable. Thus it cannot be identified with the category *foot*, which imposes both upper and lower bounds. It might be tempting to identify it with a superordinate category, some level of ‘Prosodic Word’, which would itself face a minimality requirement (but no upper bound) for structural reasons, since Prosodic Words contain at least one foot. (Approaches along these lines are explored by Spring (1990a) and Black (1991b).) But the size limitations on higher-order prosodic categories follow from conditions on foot-structure, and it is difficult to justify the foot that would be involved here. A disyllabic quantity-**insensitive** foot would be required, yet this is incompatible with the thorough-going quantity-sensitivity of prosody in Axininca Campa. There is no question that the putative disyllabic unit would need to be quantity-insensitive, to account for the prosodic variety of Reduplicants:

(47) Quantitative Structure of Disyllabic Reduplicants

- a. LL *no-na-nona*
- b. LH *n-apii-napii*
- c. HL *n-aasi-naasi*

This issue of purely syllabic requirements within quantity-sensitive prosody is of course more general than Axininca Campa; for recent discussion see McCarthy and Prince (1990b), Itô and Mester (1992), Perlmutter (1992b), and Piggott (1992).

A further way that DISYLL diverges from canonical templatic behavior is that, even as a lower bound, it is not always satisfied. Unprefixed stems like *naa-naa* have monosyllabic Reduplicants, because DISYLL is ranked below FILL, as just shown (44, 45).

These characteristics of DISYLL establish that the classical notion of template and template-satisfaction needs to be generalized. Optimality Theory provides a means for dealing effectively with the violability of the constraint; this is entirely expected behavior, in the general context of the theory. (Indeed, what requires explanation is the general *transparency* of templatic constraints, a matter we take up in §7 below.) What then of the notion *template* or *templatic constraint*?

The place to look for generalization of the notion of template, we propose, is in the family of constraints on the morphology/prosody interface, such as ALIGN. The idea is that the

Reduplicant<sup>62</sup> must be in a particular alignment with prosodic structure. The strictest such alignments will amount to classical templates. In terms of the edge-based theory of the morphology/prosody interface, DISYLL would be formalized as something like this:

(48) DISYLL (Align Version)

The left and right edges of the Reduplicant must coincide, respectively, with the left and right edges of *different* syllables.

Higher-ranking constraints, particularly SFX-TO-PRWD, ensure that all candidate Reduplicants surviving as far as DISYLL have left and right edges that coincide with syllable boundaries. Then DISYLL further requires that they be the boundaries of **different** syllables, as in the following schematization:

(49) Edge-Based DISYLL

a. <i>Obedied</i>	b. <i>Violated</i>
[no] <sub>σ</sub> [naa] <sub>σ</sub> <span style="border: 1px solid black; padding: 0 5px;">[no]<sub>σ</sub> [naa]<sub>σ</sub></span>	[no] <sub>σ</sub> [naa] <sub>σ</sub> <span style="border: 1px solid black; padding: 0 5px;">[naa]<sub>σ</sub></span>
<i>Reduplicant</i>	<i>Reduplicant</i>

This formulation of DISYLL demands a slightly richer descriptive vocabulary than ALIGN and SFX-TO-PRWD do. Below in the Appendix we show that equivalent richness is required to state the constraint RT-SFX-SEGREGATION (55), which limits the phonological compression of certain morphologically-defined sequences.<sup>63</sup> Specifically, RT-SFX-SEGREGATION asserts that a root and a suffix must straddle two different syllables. Ultimate justification for this enrichment of Align-theory would be achieved when DISYLL or some near relative is shown to do the work of the branching conditions proposed in Itô and Mester (1992) (cf. Perlmutter 1992b) to account for other cases of quantity-insensitive disyllabicity requirements in quantity-sensitive languages.

The application of DISYLL to C-final Stems /~C/ provides another illustration of the parallelism of constraint satisfaction in Optimality theory, similar to (28). The telling observation is that the epenthetic *A* required with all reduplicated C-final roots is reckoned in the satisfaction of DISYLL:

(50) C-Final Prefixed Stems /---C/

a. /C~C/ Roots		
/noñ-č <sup>h</sup> ik/	noñ-č <sup>h</sup> ik <sub>A</sub> - <u>č<sup>h</sup>ik<sub>A</sub></u> -wai <sup>T</sup> i	‘cut’
b. /V~C/ Roots		
/n-amin/	n-amin <sub>A</sub> - <u>min<sub>A</sub></u> -wai <sup>T</sup> i	‘look’
/n-oiriŋk/	n-oiriŋk <sub>A</sub> - <u>riŋk<sub>A</sub></u> -wai <sup>T</sup> i	‘lower’
/n-aacik/	n-aacik <sub>A</sub> - <u>cik<sub>A</sub></u> -wai <sup>T</sup> i	‘stop’

<sup>62</sup>Here, as with the other interface constraints, such as SFX-TO-PRWD, the edges of the Reduplicant are really the edges of the morpheme RED, of which the Reduplicant is the phonological content or exponent.

<sup>63</sup>Also see the discussion of mis-alignment constraints in §7.

The reduplicative Base is of course V-final, by epenthesis, to satisfy CODA-COND and SFX-TO-PRWD. The epenthetic vowel is repeated in the Reduplicant as required by the undominated constraint ANCHORING.

Strikingly, the epenthetic vowel in the Reduplicant counts toward the satisfaction of DISYLL. If the epenthetic vowel did not figure in the syllable count, the prefix would have to be reduplicated too in order to achieve disyllabism of the Reduplicant, yielding patterns like these:

(51) Failure to Count Epenthetic Vowel in Base Syllabism

- a. \*noñ-č<sup>h</sup>ik<sub>A</sub>-noñč<sup>h</sup>ik(Δ)
- b. \*n-amin<sub>A</sub>-namin(Δ)

In itself, this is an unremarkable consequence of the parallelist conception of constraint satisfaction in Optimality Theory. Fully-formed candidate surface representations are submitted to the constraint hierarchy, so a vowel's status as underlying or derived can have no bearing on whether it heads a syllable that satisfies DISYLL.

The standard serial conception of grammar, by contrast, cannot recruit the epenthetic vowel as part of the string that satisfies DISYLL. The problem is that the epenthetic vowel in the Base is *triggered* by the Reduplicant. How then can a copy of this vowel, which doesn't exist before the Reduplicant is created, be called on to satisfy DISYLL *in* the Reduplicant as the Reduplicant is being created? Regardless of the ordering of epenthesis and reduplication, as serial rules, the result is that the prefix is incorrectly copied:

(52) Failed Serial Derivational Attempts to Get *noñ-č<sup>h</sup>ik<sub>A</sub>-č<sup>h</sup>ik<sub>A</sub>*

- a. Epenthesis Precedes Reduplication  
noñ-č<sup>h</sup>ik+RED → *No Epenthesis* → \*noñ-č<sup>h</sup>ik-noñč<sup>h</sup>ik
- b. Reduplication Precedes Epenthesis  
noñ-č<sup>h</sup>ik+RED → noñ-č<sup>h</sup>ik-noñč<sup>h</sup>ik → \*noñ-č<sup>h</sup>ik<sub>A</sub>-noñč<sup>h</sup>ik(Δ)
- c. Cyclic or Freely-reapplying Epenthesis  
noñ-č<sup>h</sup>ik+RED → *No Epenthesis* → noñ-č<sup>h</sup>ik-noñč<sup>h</sup>ik → \*noñ-č<sup>h</sup>ik<sub>A</sub>-noñč<sup>h</sup>ik(Δ)

This problem with serial rule application is solved with parallel constraint satisfaction in Optimality Theory. Indeed, the results could not be otherwise, as long as DISYLL and the constraints responsible for epenthesis are both satisfied within a single level.<sup>64</sup>

In sum, the reduplicative behavior of prefixed stems is determined principally by the interaction of two sometimes contradictory conditions on the Reduplicant: a morphological prohibition on non-root material  $R \leq \text{ROOT}$  and a phonological requirement of minimal disyllabicity DISYLL. This constraint conflict is arbitrated in the usual way, by language-specific constraint ranking, with DISYLL dominant. The upshot is that prefixes, though present in the

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<sup>64</sup>It might be possible to account for the facts in (52) serially, by judicious statement of DISYLL. If DISYLL does not require strict disyllabicity per se, but only greater-than-monosyllabicity, then the root *.č<sup>h</sup>ik*, syllabified as shown, would presumably satisfy it. (This line of analysis is similar to the approach taken by Spring (1991) in her analysis of the velar glide phenomenon.) Of course, this makes it coincidental that the root actually does end up in a disyllable; the explanation would apply as well if the final C was left unsyllabified by the grammar and ultimately deleted.

Base, are not copied in the Reduplicant *except when* the Reduplicant would otherwise be monosyllabic.

The fact that DISYLL is violated at the surface, as in forms like *naa-naa*, shows that it must be dominated by a faithfulness constraint, FILL, shown in (45). This ranking precisely determines the intersection of the phonologically-motivated constraint hierarchy developed in §4 (v. (69) in §4) and the reduplicative constraint hierarchy of this section (§5). Using transitivity of dominance and accepting some arbitrariness in the disposition of unrankable constraint pairs, we obtain the following hierarchy of all constraints discussed to this point:

(53) Constraint Hierarchy (to Date)

Undominated Constraints	PARSE, CODA-COND FTBIN ANCHORING, CONTIGUITY  >>
Onset	ONSET  >>
Interface Constraints	ALIGN, SFX-TO-PRWD  >>
Fill	FILL  >>
Reduplicative Constraints	DISYLL >> R <sub>≤</sub> ROOT >> MAX

It is striking that the reduplicative constraints are ranked together as a block at the bottom of the hierarchy, thereby subordinating the requirements of Reduplicant form to the demands of well-formedness in prosody or the prosody/morphology interface. We will expand on this observation below, in §7.

It is also striking that the reduplicative constraints all express aspects of Reduplicant form that **any** analysis, regardless of its theoretical assumptions, must account for:

- size of Reduplicant — DISYLL
- morphological content of Reduplicant — R<sub>≤</sub>ROOT
- satisfaction of Reduplicant — MAX

There is just one essential property of the Reduplicant that these constraints do not express: its suffixal status within the morphological system of Axininca Campa. That too is a violable constraint of the reduplicative block, as we will now show.

#### 5.4 Reduplicative Compounding

The behavior under reduplication of *long* vowel-initial roots /V~~/ is a straightforward consequence of ONSET and other independently motivated constraints. But *short* vowel-initial roots behave very differently, as a result of a further interaction with DISYLL. When short vowel-initial roots /V~V/ are unprefixated, the Reduplicant and Base lie in two separate Prosodic Words

(Payne 1981:146), indicated here by the symbol ||. When these roots are prefixed, the prefix reduplicates together with the root, and the whole Reduplicant is merely suffixal, as usual.

(54) Short V-Initial Roots /V~V/

	Unprefixed		Prefixed	
/asi/	asi   <u>asi</u> -waiTaki	/n-asi/	n-asi- <u>nasi</u> -waiTi	‘cover’
/aasi/	aasi   <u>aasi</u> -waiTaki	/n-aasi/	n-aasi- <u>naasi</u> -waiTi	‘meet’
/apii/	apii   <u>apii</u> -waiTaki	/n-apii/	n-apii- <u>napii</u> -waiTi	‘repeat’

Unprefixed reduplications like *asi*||asi are Prosodic Word compounds, with the following prosodic structure:

(55) [*asi*]<sub>PrWd</sub> [asiwaitaki]<sub>PrWd</sub>

According to Payne,<sup>65</sup> there are several lines of evidence converging on the conclusion that the Base and Reduplicant are indeed segregated into separate Prosodic Words in (54). First, note the obvious hiatus in *asi.asi*; in general, Axininca Campa permits hiatus **between** Prosodic Words but not **within** Prosodic Words (because of ALIGN-L (§4.2)). Second, and independently, observe that the two Prosodic Words are treated as distinct stress domains in the Word-level phonology. The prosody is iambic and stress would ordinarily fall on the second syllable when the first is light. But final syllables are never stressed. The first PrWd displays the effects of the general prohibition on PrWd-final stressed syllables, so the stress pattern is apparently this:

(56) [*ási*]<sub>PrWd</sub> [ásiwáitaki]<sub>PrWd</sub>

Perhaps the most striking fact, though, is that the two Prosodic Words are treated as separate domains for PrWd-final vowel shortening, as shown by this example, from root /apii/:

(57) [*api*]<sub>PrWd</sub> [apiiwaitaki]<sub>PrWd</sub>

Stress and shortening (and equally, the lack of it with bimoraic Prosodic Words like *aa*||aawaitaki ‘take’) conform to completely general constraints of Axininca Campa Word-level phonology that are taken up in the Appendix.

When /V~V/ roots are prefixed, though, the Reduplicant is an ordinary suffix on the Base, as can be seen from its behavior with respect to the criteria of PrWd-hood just cited. Observe the lack of vowel shortening and the regular iambic stress of examples like these:

(58) [*napiinapii*waiti]<sub>PrWd</sub>  
[*kowà*kowawáitaki]<sub>PrWd</sub>

(The second example is phonemicized from Payne, Payne, and Santos 1982:231.) So the separation of Base and Reduplicant into two Prosodic Words is limited to the particular conditions noted in (54): a /V~V/ Stem without a prefix.

<sup>65</sup>Personal communication cited by Spring (1990a:148n.).

To understand the phonological structure of *asi//asi*, we must first understand its morphology. Though reduplication in Axininca Campa is normally suffixing, as we have argued throughout, the relationship of the Reduplicant *asi* to the base *asi* cannot be that of suffix to root, since suffixes cannot head independent Prosodic Words. This follows from the undominated<sup>66</sup> constraint PRWD $\supset$ ROOT, which has direct precedents in the sentence-phonology literature (see, e.g., Selkirk 1984:343, Kaisse 1985:39f., or Nespor and Vogel 1986:109-144):

(59) PRWD $\supset$ ROOT

Each PrWd contains a root.

Among other things, this constraint ensures that suffixes cannot relieve hiatus by PrWd compounding:

(60) /inj-koma-ako-i/

- a. \*inj-koma||ako||i
- b. inj-komaTakoTi

The multiple PrWd analysis (60) resolves hiatus without FILL violation, but is impossible because the putative Prosodic Words  $[ako]_{PrWd}$  and  $[i]_{PrWd}$  contain only suffixes, not roots.

PRWD $\supset$ ROOT further entails that the Prosodic Words  $[asi]_{PrWd}$  and  $[asiwaiTaki]_{PrWd}$  have the morphological structure in (61), since each Prosodic Word must contain a Root, and each Root must head a Stem (§3):

(61) Morphological Structure of  $[asi]_{PrWd}$   $[asiwaitaki]_{PrWd}$

(  $[asi]_{Root}$  )<sub>Stem</sub> (  $[asi]_{Root}$  -wai-ak-i )<sub>Stem</sub>

In this particular case, the Reduplicant *asi* is a **root**, not a **suffix**. Forms like *asi//asi*, then, are reduplicative **compounds**, a departure from the normal reduplicative **suffixation** of Axininca Campa. To emphasize its violability, we will characterize the normal suffixing situation in terms of a well-formedness constraint on the morphological status of the Reduplicant:

(62) R=SFX

The Reduplicant is a suffix.

That is, the Reduplicant must be a suffix on its base, as it is in all Axininca Campa reduplicated forms other than the *asi//asi* type. Violating R=SFX entails that the Reduplicant is a root instead, and so it is free to head a separate Stem and an independent Prosodic Word. Reduplicative compounds like *asi//asi* violate this constraint, but all other Reduplicants obey it.

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<sup>66</sup>Little is known about the sentence phonology of Axininca Campa, so it is impossible to say whether or not PRWD $\supset$ ROOT is dominated at Phrase level. It seems likely that it is, since similar constraints are violated in the phrase phonology of more familiar languages like English, where functional categories are promoted to PrWd-hood under focus, at the peripheries of constituents, and so on.

The location of R=SFX in the Axininca Campa constraint hierarchy can be determined almost exactly. The first ranking relation can be deduced from the case where R=SFX is violated and therefore dominated. The most harmonic failed candidates are those which imitate the usual pattern for long V-initial roots /V~/, loss of the initial onsetless syllable from the Reduplicant. Their only distinguishing violation is of the constraint DISYLL:

(63) DISYLL  $\gg$  R=SFX Ranking Argument

Candidates	DISYLL	R=SFX
☞ asi  asi		*
asi-si	* !	
☞ apii  apii		*
apii-pii	* !	

As is clear from the tableau, DISYLL must dominate R=SFX, compelling the abandonment of suffixal status of the Reduplicant in favor of root compounding.

The other ranking argument comes from a case where the suffixal status of the Reduplicant is *preserved* in the face of a constraint that could in principle force compounding: MAX.<sup>67</sup> The observation is that reduplicative compounding is not possible with forms like unprefixes /osampi/, as a way to copy the initial syllable:

(64) R=SFX  $\gg$  MAX Ranking Argument

Candidates	R=SFX	MAX
☞ osampi-sampi		*
osampi  osampi	* !	

The two candidates tie on all higher-ranking constraints (including ONSET - v. (66) below). We conclude from this that R=SFX dominates MAX, ensuring that violation of MAX — incomplete copying — will be embraced to preserve the purely suffixal status of the Reduplicant.

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<sup>67</sup>Reference to MAX and the other copying constraints, ANCHORING and CONTIGUITY, in compounding reduplication raises a minor technical issue. Recall (from §5.2) that the Base is defined as “the phonological material that immediately precedes the exponent of the suffix morpheme”. Throughout §5, we have assumed that the compounded Reduplicant bears the same linear relation to its Base as the suffixed Reduplicant: it follows it. Thus, we may make the obvious and natural generalization of Base as the phonological string preceding the Reduplicant, whether the Reduplicant is a suffix or a member of a compound. Hence the Reduplicant/Base relation is governed by the same constraints — MAX, ANCHORING, and CONTIGUITY — regardless of what the morphological relation between Base and Reduplicant is.

R=SFX and the remaining reduplicative constraint,  $R \leq \text{ROOT}$ , never interact in a rankable way because the obvious test cases — *n-apii-napii* vs. \**n-apii||apii* — are distinguished by higher-ranking ONSET. Thus, the complete hierarchy of dominated reduplicative constraints must be as follows:

(65) Dominated Reduplicative Constraints

DISYLL >>  
 R=SFX,  $R \leq \text{ROOT}$  >>  
 MAX

We will explore this ranking and the role of these constraints further in §5.5 below.

Thus far, we have used facts to establish pairwise rankings among relevant constraints; this places a set of necessary conditions on the hierarchy: if any hierarchy of these constraints will work, it must meet these ranking requirements. To complete the argument, as usual, we need to show that the hierarchy we have put together is *sufficient*: that all nonoptimal candidates are rejected. Because the possibility of PrWd compounding considerably enriches the candidate space, this is a matter of some complexity and delicacy. Two basic situations arise: where the candidates are structurally heterogeneous, some involving simple suffixation X+Y, as we have seen throughout, and others being compounds X||Y; and where the candidates compared are all PrWd-compounds X||Y.

The first issue to consider is this: how are candidates consisting of a single Prosodic Word compared with candidates containing several Prosodic Words? We propose that the evaluation of optimality is local to each Prosodic Word, except with constraints that, by their very nature, transcend the boundaries between Prosodic Words.

In Optimality Theory, the domain in which candidates are evaluated can be specified by articulating the notion of Harmonic Ordering (v. §2 and Prince and Smolensky 1993:§3), which provides a general means of comparing two constraint-violation records. To rank them, compare their worst (highest-ranking) violation-marks; if they tie, omit those marks and try again. To ensure that evaluation of candidates is local to each PrWd, we assume that violations of constraints like ONSET are grouped by PrWd; the function returning the “worst mark” scans each such group in parallel, returning a mark if it finds any among the groups. Constraints that apply between PrWd’s will not impose any such sub-grouping on their violation-sets, and evaluation will proceed in the normal fashion.

This matter is of more than just passing interest, since the locality of evaluation is important to understanding the role of ONSET in Axininca compounding reduplication. Consider the following comparison between candidates with compounding total reduplication and suffixing partial reduplication:

(66) ONSET in Compounding vs. Suffixation

	ONSET
a. $\text{apii}  \text{apii-waiTaki}$	*    *
b. * $\text{apii-pii-waiTaki}$	*

The two candidates obey all of the undominated constraints of Axininca Campa; under the PrWd-bounded sense of Harmonic Ordering proposed above, they also tie on ONSET, leaving the

choice up to DISYLL, which correctly selects (66a). They tie on ONSET because the evaluation proceeds in parallel for each of the PrWd-grouped sets in (66a), and each individual Prosodic Word in (66a) ties with the single Prosodic Word (66b). The effect of refining Harmonic Ordering so as to bound ONSET and other constraints in this way is that each Prosodic Word is a separate domain of assessment, as we have indicated by the boundary symbol || in (66a). (An informal rule of thumb for inspecting tableaux is that marks are not additive across ||.)

The second issue is the comparison of PrWd compounds with each other. What of the comparison in (67), where a violation of ONSET is spared by less-than-full copying?

(67) Partial Reduplication in PrWd Compounding

	ONSET
a. $\text{a}^{\text{a}}\text{apii}  \text{apii}\text{-wai}\text{T}^{\text{a}}\text{aki}$	*    *
b. * $\text{apii}  \text{pii}\text{-wai}\text{T}^{\text{a}}\text{aki}$	*

ONSET may be violated PrWd-initially because it is dominated by ALIGN-L, as explained in §4.2, but seemingly gratuitous violation of ONSET will always be avoided, as it is in (67b). Though DISYLL or MAX would select (67a) over (67b), both DISYLL and MAX are ranked below ONSET,<sup>68</sup> so neither can have any effect here.

The explanation for the non-optimality of (67b) is quite simple. The Reduplicant *pii* is not a root of Axininca Campa, so *piiwaiTaki* violates undominated PRWD>ROOT (59). Suffixing reduplication may be incomplete, as indeed it is with long V-initial roots, as in *osampi-sampi* or *n-osampi-sampi* (§§5.2, 5.3). But in Axininca a compounded Reduplicant must include the whole root, because each Prosodic Word in the compound must be headed by an actual root of the language. The totality of compounding reduplication is unrelated to MAX. (MAX and the copying constraints will, however, ensure that each member of a reduplicative compound is headed by the **same** root.)

The following tableaux gather all of the more harmonic candidates for the reduplication of /apii/ and /n-apii/, assessing them according to the relevant constraints as explicated above:

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<sup>68</sup>The ranking of DISYLL below ONSET follows from transitivity: ONSET >>FILL (§4.2) and FILL >>DISYLL (§5.3). The argument that MAX is ranked below ONSET is direct, based on /V~V/ reduplications like *osampi-sampi* (§5.2).

(68) Without Prefix: /*apii*-RED/

Candidates	PRWD $\supset$ ROOT	ALIGN-L	ONSET	DISYLL	R=SFX	MAX
<i>apii</i> - <u><i>pii</i></u>			*	* !		*
<i>apii</i>    <u><i>pii</i></u>	* !		*	*	*	*
[T  <i>apii</i> -T <u><i>apii</i></u>		* !				
<i>apii</i> . <u><i>apii</i></u>			** !			
$\text{↻}$ <i>apii</i>    <u><i>apii</i></u>			*    *		*	

Remarks:

- \**apii*||*pii* violates undominated PRWD $\supset$ ROOT, as explained above (67).
- \**Tapii*-T*apii* violates ALIGN-L (§4.2), which bars PrWd-initial epenthesis.
- In the surviving candidates, each Prosodic Word contains a single ONSET violation, except for \**apii*.*apii*, so it is rejected.
- \**apii*-*pii*, with a monosyllabic Reduplicant, fails DISYLL.
- Other C-epenthetic candidates not listed, such as \**apii*-T*apii* and \**apiiT*-*apiiT*, all violate constraints that dominate DISYLL, including FILL, SFX-TO-PRWD, ALIGN, ANCHORING, and CONTIGUITY, and fail for the reasons discussed with respect to the long V-initial roots in §5.2, (18).
- $\text{↻}$  *apii*||*apii* is left as the only viable candidate. It at least ties on ONSET with other candidates and otherwise violates only the low-ranked R=SFX.

(69) With Prefix: /*n*-*apii*-RED/

Candidates	ONSET	DISYLL	R=SFX	R $\leq$ ROOT	MAX
<i>n</i> - <i>apii</i> - <u><i>pii</i></u>		* !			*
<i>n</i> - <i>apii</i> . <u><i>apii</i></u>	* !				*
<i>n</i> - <i>apii</i>    <u><i>apii</i></u>	* !		*		*
$\text{↻}$ <i>n</i> - <i>apii</i> - <u><i>napii</i></u>				*	

Remarks:

- \**n*-*apii*||*apii*, the only novel candidate, crucially violates ONSET.
- *n*-*apii*-*napii* is the only surviving candidate and the actual output form.

Violations of R=SFX will occur with several other root types besides /VCV/. Roots of the form /VC/ must, like other consonant-final roots, be parsed with final epenthetic *A* when

reduplicated, as required by CODA-COND, SFX-TO-PRWD, ANCHORING, and ALIGN (cf. (9, 15, 22, 50)):

(70) Short, V-Initial, C-Final Roots /VC/

	Unprefixed		Prefixed	
/ak/	akA  akA-waiTaki	/n-ak/	n-akA-nakA-waiTi	‘answer’.
/ook/	ookA  ookA-waiTaki	/n-ook/	n-ookA-nookA-waiTi	‘abandon’

The account of these forms is virtually the same as /asi/, except that a candidate without epenthetic *A* must also be given serious consideration:

(71) /ook-RED/

Candidates	ONSET	SFX-TO-PRWD	FILL	DISYLL	R=SFX
oo.]k oo.k~	*	* !		*	
oo.kA.] oo.kA~	** !		**		
☞ oo.kA.  oo.kA	*    *		**		*

The candidate \**ook-ook* (or \**ookAT-ookAT*, for that matter) has a consonant-final Base, crucially failing SFX-TO-PRWD. In contrast, *ookA||ookA* vacuously satisfies SFX-TO-PRWD, because the Reduplicant is not a suffix. The comparison of *ookA||ookA* with \**ookA.ookA* proceeds by Prosodic Words, as in (66); double ONSET violation in a single Prosodic Word is fatal to \**ookA.ookA*. Another possible candidate, \**ookA||ook~*, violates ANCHORING and ALIGN in a by-now familiar way.

Another condition that leads to reduplicative compounding in Axininca Campa is a root of the shape /V/ — vowel-initial, vowel-final, and monomoraic, so augmentation is demanded by SFX-TO-PRWD. The outcome in this case is as we would expect, combining augmentation with reduplicative compounding:

(72) Unprefixed Stem /V/

/i/      iTA||iTA-waiTaki      ‘has continued to precede more and more’ (Spring 1990c:147)

This result follows directly from the analysis we have presented. Though the actual output form violates FILL, R=SFX, and R≤ROOT (since the Reduplicant contains epenthetic material), all of the alternatives fare worse:

- \**i.i* and \**i.TA.i.TA* are Prosodic Words containing multiple ONSET violations, inferior (according to (66)) to *iTA||iTA*.
- \**iTA||i* violates the undominated copying constraint ANCHORING, which demands faithful copying of the material at the right edge of the Base.
- \**iT|iT* violates SFX-TO-PRWD, since the Reduplicant is preceded by *iT*, an impossible (because consonant-final and monomoraic) Prosodic Word.
- \**iTA]T|iTAT* violates SFX-TO-PRWD as well.

The root /i/ augments as *.i/.TA.* rather than *\*.i/i.* because of ALIGN, as we showed above in §4.2.

A final example. Combining a /V-/ prefix with a monoconsonantal /C/ root at the Prefix level creates a /V-C/ Stem, which reduplicates just like a /VC/ root:

(73) Prefixed Stem /V-C/

/o-p/ o-wA||owA-wai<sup>̣</sup>Caawoota ‘that she might feed her continually more and more’

In this word, the root is /w/, lenited at Prefix level from /p/ when combined with the prefix /o-/ ‘causative’. The interest of this case is the especially poor performance of the optimal form on the reduplicative constraints, violating both R=SFX and R≤ROOT:

(74) /o-w-RED/ (lenited from /o-p-RED/)

Candidates	ONSET	SFX-TO-PRWD	FILL	DISYLL	R=SFX	R≤ROOT	MAX
o-w ow	*	* !		*		*	
o-wA]  wA	*		**	* !		*	*
o-wA]  .owA	** !		**			**	
☞ o-wA  owA	*    *		**		*	**	

Here again we have a dramatic instance of what Prince and Smolensky (1993) refer to as “the strictness of strict domination.” The optimal form incurs a total of seven marks, and it violates two of the four constraints on the Reduplicant. Alternative candidates without these liabilities are available, but to no avail. The alternatives all have a single crucial violation of some dominant constraint, dismissing them from further consideration.

\* \* \*

Examination of this final reduplicative pattern of Axininca Campa reveals that even the Reduplicant’s status as a suffix is among the violable constraints of the language, R=SFX. The constraint ONSET compels less-than-full reduplication of /V~~V/ roots; with /V~V/ roots, ONSET combines with DISYLL to select a candidate where the Reduplicant is in a separate Prosodic Word from the Base.

On reflection, this seems quite a remarkable result: a phonological well-formedness constraint (ONSET), in concert with a morphological one (DISYLL), is responsible for determining whether the reduplicative morphology is suffixing or compounding. Though it emerges as a natural consequence of the analysis presented here, and of Optimality Theory in general, it is difficult to imagine how this finding could be expressed in other approaches. The best shot at a rule-based serial analysis would be a repair strategy inserting a Prosodic Word boundary (really,  $\emptyset \rightarrow \#$ ) medially in /asi-asi/, to relieve the hiatus (cf. §6 below for discussion of a similar proposal). But boundary insertion rules like this are a patent absurdity, and all sophisticated current conceptions of phonological theory rightly reject them. Thus, compounding reduplication provides the last and most striking argument for parallel satisfaction of constraints pertaining to a variety of different levels of phonological and morphological structure.

## 5.5 Constraints on the Reduplicant

The evidence and analysis we have presented argue for the existence of a block of constraints on Reduplicant form, ranked below all other visibly active constraints of the language, in the following hierarchy:

### (75) Constraint Hierarchy

Undominated Constraints	PARSE, CODA-COND FTBIN, ALIGN-L ANCHORING, CONTIGUITY  >>
Onset	ONSET  >>
Interface Constraints	ALIGN, SFX-TO-PRWD  >>
Fill	FILL  >>
Reduplicative Constraints	DISYLL >> R=SFX, R≤ROOT >> MAX

It is appropriate at this stage to take stock of the results, examining the status and parochial ranking of the block of dominated reduplicative constraints, preparatory to considering alternative accounts in §6 and the general ranking of these constraints with respect to the rest of the phonology in §7.3.

The dominated reduplicative constraints, as promised, all characterize properties of the Reduplicant that any analysis must take note of, whatever its descriptive vocabulary. DISYLL demands a Reduplicant of a certain minimal size, a kind of generalized templatic restriction. R=SFX describes the Reduplicant's structural role in the morphological system of Axininca Campa. R≤ROOT characterizes the morphological composition of the source of the Reduplicant, demanding a kind of morphological integrity. Finally, MAX is a familiar feature of reduplicative theory whose role in Axininca Campa, as in all languages, is to require that the Reduplicant be an exact copy of its base.

In one sense, then, the constraints on the Reduplicant we have posited are entirely familiar, a matter of almost routine necessity in any analysis of a reduplicative system. What raises them above the hum-drum is this: *none is true*. No constraint of the four expresses a surface-true, unviolated generalization of the language. Sometimes the Reduplicant is monosyllabic, in violation of DISYLL: *naa-naa*. Sometimes the Reduplicant is a compounded root, rather than a suffix, in violation of R=SFX: *asi//asi*. Sometimes the Reduplicant contains affixal or epenthetic material, in violation of R≤ROOT: *no-naa-nonaa*, *naTA-naTA*. And often enough the Reduplicant is an inexact copy of the base, violating MAX: *noŋ-kawosi-kawosi*, *osampi-sampi*.

Of course, the literal untruth of the constraints on the Reduplicant is not a flaw in the analysis; on the contrary, it is a fundamental result of Optimality Theory. The ranking of the reduplicative constraint block at the bottom of the hierarchy, below the constraints on prosodic structure, the prosody/morphology interface, and FILL, is sufficient to ensure that the reduplicative constraints will be violated in one surface form or another. (Indeed, violation is the only argument for the crucial domination of a constraint.) These demands on Reduplicant form are subordinate to all other requirements of prosodic well-formedness, a point explored further in §7.3 below.

We have also argued for a strict ranking among the four constraints on the Reduplicant. This is obviously a matter of descriptive necessity, since the individual rankings are supported by specific empirical arguments:

(76) Motivated Rankings of Constraints on the Reduplicant

Ranking	Candidate Comparison	Descriptive Generalization
DISYLL $\gg$ R=SFX	<i>apii</i>    <u><i>apii</i></u> > * <i>apii</i> - <u><i>pii</i></u>	A compounded Reduplicant is chosen over a monosyllabic one.
R=SFX $\gg$ MAX	<i>osampi</i> - <u><i>sampi</i></u> > * <i>osampi</i>    <u><i>osampi</i></u>	Less-than-full reduplication material is chosen over a compounded Reduplicant.
R $\leq$ ROOT $\gg$ MAX	<i>noŋ-kawosi</i> - <u><i>kawosi</i></u> > * <i>noŋ-kawosi</i> - <u><i>nonkawosi</i></u> , <i>n-osampi</i> - <u><i>sampi</i></u> > * <i>n-osampi</i> - <u><i>nosampi</i></u>	An inexact Reduplicant is chosen over one containing non-root material.
DISYLL $\gg$ R $\leq$ ROOT	<i>no-naa</i> - <u><i>nonaa</i></u> > * <i>no-naa</i> - <u><i>naa</i></u> , <i>n-<u>apii</u></i> - <u><i>napii</i></u> > * <i>n-<u>apii</u></i> - <u><i>pii</i></u>	A Reduplicant containing non-root material is chosen over a monosyllabic one.

The parochial rankings of the constraints on the Reduplicant have been justified by specific empirical observations like these, rather than on the basis of general considerations of logic or claims about Universal Grammar.

This point is of some interest, since Optimality Theory asserts that, in the general case, the ranking of constraints is part of the grammar of individual languages, though the constraints themselves are (parametrized) universals. The interaction of constraints on Reduplicant form in Axininca Campa supports that, and we can pin the claim down more firmly by asking whether various rearrangements of the Axininca Campa Reduplicant constraint hierarchy lead to plausible (or even existing) systems of reduplication. As far as we can determine, they do.

Reversal of the ranking between DISYLL and R=SFX seems, if anything, more plausible than the situation we observe in Axininca Campa. With R=SFX in the dominant role, reduplicative compounding is disfavored, and so *apii*-*pii* is the output. Since reduplicative compounding in alternation with reduplicative suffixation is perhaps the most unusual feature of Axininca Campa reduplication, it is safe to say that dominant R=SFX has a place in the world's languages.

Reversal of the ranking between R=SFX and MAX would choose *osampi*||*osampi* as the output form, so all /V~/ roots, short or long, would exhibit reduplicative compounding. Since, as we just noted, the alternation between suffixation and compounding observed in Axininca Campa is not typical of other languages, it is not clear whether exercising this option further

would be the expected outcome in some other system. In this case, then, we have no strong view on the plausibility of the language-particular ranking required.

The constraints  $R \leq \text{ROOT}$  and  $\text{MAX}$  make exactly competing demands on the optimality of the Reduplicant. As we noted earlier (v. §5.3), the reversed ranking renders  $R \leq \text{ROOT}$  completely invisible, a typical situation in constraint interaction when a specialized constraint conflicts with a more general one (Pāṇini's Theorem). Under that condition, the constraint  $\text{MAX}$  is satisfied fully, and total reduplication, without regard to the morphological composition of the base, ensues.

An interesting overall picture of the reduplicative constraints and their ranking in Axininca Campa has emerged. The constraints on the Reduplicant express properties of it that any analysis must take note of. But none of these constraints hold exceptionlessly at the surface, because all are dominated by requirements of prosodic form and the prosody/morphology interface. Furthermore, within the set of reduplicative constraints, there is an empirically justified, language-particular ranking. These constraints and their possible re-rankings provide a natural account of a plausible range of interlinguistic variation, of which Axininca Campa is just a part.

## 6. Comparison with Other Analyses of Axininca Campa Reduplication

Our analysis of Axininca Campa reduplication has been presented in its entirety. Later, in the Appendix, we will turn to the Word-level phonology of this language, but it is appropriate now to step back from the particular details of our analysis and reflect on how the insights of Optimality Theory can be applied to previous accounts of this language. We will focus on Spring's (1990a) "Base Copy" model, together with some refinements proposed by Black (1991b), and a "Full Copy" analysis inspired by Steriade's (1988a) conception of how templates are to be satisfied in Prosodic Morphology. We will see that these approaches, despite differences of detail, must ultimately refer to notions that are equivalent to constraint dominance and violability. In an abstract sense, then, all of these alternatives invoke something very like Optimality Theory, offering compelling assurance that our analysis and the theory itself are on the right track.

The essential idea in Spring's (1990a) Base Copy analysis of Axininca Campa reduplication is specification of the PrWd Base (cf. §4.3 above) — that is, the morpheme RED delimits a Prosodic Word as the base to which it is suffixed. Indeed, once the PrWd Base of reduplication is properly delimited, the rest of the derivation is trivial, consisting of simply making an exact copy of the PrWd Base by the same mechanisms called on in rules of total reduplication. Thus, refinements of PrWd Base delimitation account for all of the various complications in the data. The relevant cases are analyzed as follows:

- *kawosi–kawosi, noŋ-kawosi–kawosi*

To account for the lack of prefix reduplication with long roots, Spring attributes the following structure to verbs: [prefix–[root–RED]]. In this way, the prefix is not within the scope of the PrWd Base delimited by RED on the inner cycle, where the reduplicative suffix is added. Hence, the prefix is not part of the delimited PrWd, and so it is not copied.

- *no-naa–no-naa, no-na–no-na*

Spring (1990a:74-76; cf. Spring 1992) assumes that the PrWd is minimally disyllabic. Thus, delimitation of a PrWd Base by RED in [*no*–[*naa*–RED]] or [*no*–[*na*–RED]] fails. The string is therefore rebracketed to [*no-naa*–RED], and PrWd Base specification is successful, because *no-naa* is disyllabic.

- *naa–naa*

When the Base is monosyllabic and unprefixed, delimitation of a disyllabic PrWd fails, and of course rebracketing is not an option. In this case, the minimal realization of PrWd, as bimoraic rather than disyllabic, is accepted, so the Base *naa* is delimited and copied.

- *osampi–sampi*

According to Spring (1990a:37-44), initial onsetless syllables are extrametrical, so they cannot be incorporated into the PrWd Base of reduplication. Thus, only *sampi* is delimited and copied.

- *n-osampi–sampi*

The root-initial onsetless syllable of *osampi* is extrametrical (indicated by ⟨⟩) because it meets the Peripherality Condition on the inner cyclic domain, where PrWd Base delimitation applies: [*n*–[⟨*o*⟩*sampi*–RED]]. Thus, only the intrametrical portion *sampi* is accessible to PrWd Base delimitation.

•*n-asi-n-asi, n-apii-n-apii, n-aasi-n-aasi*

In the input [*n-⟨a⟩si-RED*], the root-initial syllable is extrametrical on the inner cyclic domain. But the intrametrical portion *si* does not satisfy the disyllabicity requirement of PrWd Base delimitation. As in *no-naa*, this exigency forces rebracketing to [*n-⟨a⟩si-RED*], the Peripherality Condition revokes extrametricality, and the entire string *n-asi* is the delimited PrWd Base.

•*asi//asi, api//apii, aasi//asi*

Though Spring (1990a) does not discuss this case explicitly, it seems reasonable to assume (with Black (1991a)) that delimitation of a disyllabic PrWd Base fails because the initial onsetless syllable is extrametrical. Therefore extrametricality is revoked, and then PrWd Base delimitation proceeds normally.

•*naTA-naTA, pAA-pAA*

A monomoraic or shorter unprefixated root cannot be parsed as a disyllabic PrWd, it cannot be made disyllabic by rebracketing or revocation of extrametricality, and it does not match the second-rate bimoraic PrWd. Since all else fails, the PrWd Base is (minimally) satisfied by augmentation to bimoraicity.

Black's (1991b) version of the Base Copy analysis is virtually the same as Spring's, except that he proposes that syllables containing prefixal material are also extrametrical. Prefixal extrametricality allows him to assume the more natural bracketing [*⟨noŋ⟩-kawosi-RED*], with the prefix outside the scope of PrWd Base delimitation by virtue of extrametricality. Similarly, in an example like [*⟨n-o⟩sampi-RED*], the entire syllable containing the prefix *n-* is extrametrical. Like extrametricality of onsetless syllables, extrametricality of prefixal syllables is revoked when necessary to satisfy the PrWd Base: *⟨n-a⟩si-RED* → *n-asi-RED* → *n-asi-n-asi*.

A striking property of the Base Copy analysis, apparent from this brief sketch, is its reliance on locutions like “do X except when PrWd is not satisfied, otherwise do Y”. Examples of this include all of the following:

(1) “X except Z else Y” in Base Copy Analysis

- a. The structure of verbs is [prefix-[root-RED]] except when PrWd is not satisfied, otherwise rebracket to [prefix-root-RED].
- b. A prefixal syllable is extrametrical except when PrWd is not satisfied, otherwise revoke extrametricality.
- c. An initial onsetless syllable is extrametrical except when PrWd is not satisfied, otherwise revoke extrametricality.
- d. Do any of the above and delimit a disyllabic PrWd Base. If PrWd is not satisfied, delimit a bimoraic PrWd.
- e. Do any of the above and if PrWd is not satisfied, augment to bimoraicity.

This remarkable parallelism throughout the Base Copy analysis is no accident; as Prince and Smolensky (1993:§4) observe, the “do something except when” pattern of blocking or revocation is a typical property of analyses that combine rules and well-formedness conditions. A specific requirement — in this case, that the PrWd Base is disyllabic — forces violation of a variety of

very general requirements — prefixal syllables are extrametrical, onsetless syllables are extrametrical, and so on.

The “do something except when” locution that is so characteristic of the Base Copy analysis has a natural interpretation within Optimality Theory. The requirement that a PrWd be disyllabic overrides other, lower-ranking well-formedness requirements, such as extrametricality. Thus, it is a relatively simple matter to re-cast the statements in (1) as assertions about constraint domination:

(2) Base Copy Analysis as Constraint Domination

- a.  $\text{PrWd}_{\geq\sigma\sigma} \gg [\text{prefix} - [\text{root} - \text{RED}]]$
- b.  $\text{PrWd}_{\geq\sigma\sigma} \gg \text{Prefixal syllable extrametrical}$
- c.  $\text{PrWd}_{\geq\sigma\sigma} \gg \text{Onsetless syllable extrametrical}$
- d.  $\text{Base} = \text{PrWd}_{\geq\mu\mu} \gg \text{Base} = \text{PrWd}_{\geq\sigma\sigma}$
- e.  $\text{PrWd}_{\geq\mu\mu} \gg \text{Don't augment (FILL)} \gg \text{PrWd}_{\geq\sigma\sigma}$

For example, (2a) says that disyllabicity of the PrWd overrides the preferred relationship among prefix, root, and Reduplicant in Spring’s analysis of the verbal morphology. Similarly, (2b) describes in terms of constraint satisfaction, rather than serial rule application, the revocation of prefixal extrametricality under the same requirement of PrWd well-formedness.

What this means is that Base Copy analysis, once it is more fully formalized, necessarily depends on something very much like Optimality Theory. The core of the Base Copy model is a set of constraints on the morphological and prosodic structure of the base; (2) shows that they interact in precisely the way that Optimality Theory predicts. At this abstract level, then, our analysis and the Base Copy model are very much in agreement.

Despite this common conceptual underpinning, there are important differences between these other accounts and the one presented here. The principal loci of difference are the use of extrametricality, the morphological status of prefixes, bimoraicity versus disyllabicity, and reduplicative compounding.

The Base Copy analysis requires extrametricality of initial onsetless syllables to account for their reduplicative behavior, but all other evidence shows that they are *intrametrical*.<sup>69</sup> Initial onsetless syllables participate fully in the left-to-right assignment of iambic stress (below, (12)). Final vowel shortening (26) is inapplicable to bimoraic words (25), but it applies freely to words that consist of two moras plus an initial onsetless syllable: /ampii/ → *ampi* ‘cotton’. Thus, the extrametricality required to implement Base Copy must be prevented from having any other effects in the phonology or morphology.<sup>70</sup> Extrametricality of prefixal syllables presents similar problems, since prefixes also participate fully in the prosodic phonology of Axininca Campa.

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<sup>69</sup>Another argument for extrametricality of initial onsetless syllables, based on the phonology of the unique root /irau/, is discussed in the Appendix (§A.3).

<sup>70</sup>Compare this with the analysis presented in §4 and §5. In §4.2, the existence of vowel-initial words is attributed to the constraint ALIGN-L, which is also crucially called on to bar prothetic augmentation (§4.3). And in §5.2, the non-copying of initial onsetless syllables in reduplication is attributed to ONSET, which is, of course, an essential constraint in Axininca syllabic phonology (§4.2).

Since stress and vowel shortening are Word-level phenomena, as we argue in the Appendix, one could perhaps claim that extrametricality of initial onsetless or prefixal syllables holds at Suffix level, thereby affecting reduplication, but is revoked at Word level. But even this weaker hypothesis is incorrect, as shown by two observations. First, Axininca Campa has no monomoraic noun roots, but it does have noun roots consisting of a single mora plus an onsetless initial syllable: *ana* ‘black dye’, *oŋko* ‘edible plant’, *ampi* ‘cotton’. Root minimality is obviously a lexical requirement (invoked by Root=PrWd (§7.4 and McCarthy and Prince 1991a)), so it cannot be postponed until Word level.

Another lexical phenomenon that treats initial onsetless syllables as *intrametrical* is the allomorphy of the genitive suffix *-ti*. This morpheme takes the allomorph *-ni* with bimoraic roots:

(3) Genitive Suffix Allomorphy (Payne 1981:101f.)

a. Root /C~/

no-maini-ti	‘my bear’
no-t <sup>h</sup> oŋkiri-ti	‘my hummingbird’
no-manaasawo-ti	‘my turtle’
no-č <sup>h</sup> iriwito-ti	‘my kingfisher’

b. Root /V~/

n-airi-ti	‘my bee’
n-iirisi-ti	‘my new leaf’
n-aawana-ti	‘my mahogany’
n-ananta-ti	‘my orchid’
n-opimpi-ti	‘my toucan’
n-ačaapa-ti	‘my hen’

c. Root /C~/

no-mii-ni	‘my otter’
no-soo-ni	‘my sloth’
no-mapi-ni	‘my rock’
no-c <sup>h</sup> iŋki-ni	‘my eel’
no-kor <sup>v</sup> a-ni	‘my manioc worm’

d. Root /V~/

n-it <sup>h</sup> o-ni	‘my swallow (bird)’
n-iŋki-ni	‘my peanut’
n-ana-ni	‘my black dye’
n-oŋko-ni	‘my edible plant’

The root’s length in moras is the sole determinant of the genitive allomorph. Long vowel-initial roots (3b) and long consonant-initial roots (3a) are treated alike, and short vowel-initial roots (3d) take the *-ni* allomorph just like short consonant-initial roots (3c). These facts are incompatible with initial extrametricality, regardless of what assumptions are made about morphological bracketing. If the morphological bracketing is assumed to be [*no*-[root-*ti/ni*]], then onsetless syllable extrametricality on the inner cycle will make many of the roots in (3b) bimoraic, incorrectly selecting the *-ni* allomorph: \*[*n*-[<*aa*>*wana-ni*]]. Yet if the bracketing is

[[*no-root*]-*ti/ni*], then prefixal syllable extrametricality will have the same wrong effect: \*[[<*n-aa*>*wana*]-*ni*]. Either way, extrametricality is a problem.

The assumptions about morphological bracketing that account for prefixal reduplication in one version of the Base Copy analysis also present difficulties. The bracketing [prefix+[root+RED]] presupposes that no phonology between prefix and root will occur before reduplication. On the contrary, as we argue above in §3, the Prefix-level phonology must precede or at least be simultaneous with the Suffix-level phonology. Remarkable confirming evidence that prefixal phonology must precede reduplication specifically is provided by the following example:

(4) /no+o+piinjka+RED/      no-wiinjka-wiinjka      ‘1st+caus.+submerge+more and more’

In this form, the causative prefix *o-* has triggered lenition of initial *p* in both Base and Reduplicant, requiring Prefix-level phonology no later than reduplication. Moreover, the prefixal phonology works exactly the same in supposedly rebracketed forms like *owa//owa*, from underlying /o+o+p+RED/ ‘3rd fem. + caus. + feed + RED.’. True morphological rebracketing would be expected to lead to some differences in the interaction between reduplication and the prefix-level phonology.

The ambiguity between a bimoraic and a disyllabic PrWd Base is never successfully resolved (cf. Spring 1990a:152f., 1990b, 1992 and the critique in Golston 1991). To account for why reduplication yields *n-apii-n-apii* and not \**n-apii-pii*, morphological rebracketing must respond to a disyllabicity requirement. Yet to account for why /p/ augments as *pAAA-pAAA* but /naa/ doesn’t augment at all (e.g., *naa-naa*), the PrWd-Base must impose a bimoraicity requirement. In contrast, in the analysis presented in §4 and §5, bimoraicity is demanded of the Base (by SFX-TO-PRWD and FOOT-BINARITY) while disyllabicity is a completely separate constraint on the Reduplicant (enforced by DISYLL). The Base Copy analysis, by its very nature, cannot impose separate requirements on Base and Reduplicant.

One approach to this problem, with an explicit tie to earlier work in Optimality Theory, is Black’s (1991a, 1991b) “Optimal Iamb” proposal. Prince (1991) argues that there is a scale of foot optimality: LH > {H, LL} > HL > L. Black extends this idea, claiming that the PrWd minimality requirement is defined by the *iambic* optimization scale LH > LL > H > L. For example, in forms like *n-asi-n-asi* or *n-apii-n-apii*, prefixal extrametricality is overridden in order to achieve a net improvement on the optimization scale. Likewise, augmentation of unprefixal /<sup>h</sup>o/ as *t<sup>h</sup>oTAA* and not \**t<sup>h</sup>oo* follows from the preference LL > H in the optimization scale.

This move solves some problems, but similar ones remain. Though revoking extrametricality in <*no-*>*naa* or <*n-a*>*pii* trades one type of iamb (H) for a higher rated one (LH), revoking it in <*n-aa*>*si* trades a dispreferred iamb (L) for something that is not an iamb at all (HL). Furthermore, it is not explained why augmentation applies only to L roots like /naa/ and why it yields only LL like *naTAA*. Why shouldn’t augmentation yield LH \**naTAA*, and why shouldn’t other non-optimal root types seek augmentational improvement on the iambic scale as well? In any case, as Spring (1991) notes, the iambic scale incorrectly predicts that /p/ will augment to \**paTAA* rather than *pAAA*.

Finally, the reduplicative compounding of *asi*//*asi* has not been dealt with convincingly in Base Copy theory.<sup>71</sup> Based on an observation by David Payne that the hiatus is realized as *ʔ* in slow speech, Black (1991b) claims that initial *ʔ* is part of the underlying representation of these roots: /*ʔasi*/, /*ʔaasi*/, /*ʔapii*/. Hence, the roots are actually consonant-initial, so they are not subject to extrametricality and will reduplicate to yield /*ʔasi-ʔasi*/ and so on. He goes on to propose that a postlexical rule interprets the word-medial *ʔ* as a word boundary, which we notate by  $\|$ . But this analysis entails that all vowel initial roots, short or long, should have initial *ʔ*. Hence there are no true vowel-initial roots, and so no role in the language for extrametricality of initial onsetless syllables. Moreover, it follows that underlying /*ʔosampi*/ should reduplicate as \**osampi*//*osampi*. There are many small problems as well, such as the peculiarly restricted distribution of the putative phoneme /*ʔ*/, the need to delete /*ʔ*/ after all prefixes, and the odd rule transforming *ʔ* into a word boundary.

We turn now to an analysis we have constructed according to our understanding of Steriade's (1988a) "Full Copy" model of reduplicative template satisfaction in Prosodic Morphology.<sup>72</sup> In this approach, a full copy of the entire Base is made and then is reduced to satisfy a prosodic template by various truncation rules. Since Steriade does not discuss any cases comparable to Axininca Campa and notes that "much remains to be determined about the exact nature of the satisfaction procedures" (Steriade 1988a:83), our application of the Full-Copy approach to this language is largely conjectural.

With these qualifications in mind, we propose the following truncation rules as a first approximation to a Full-Copy analysis of Axininca Campa:

#### (5) Full Copy Analysis (First Version)

- a. Delete prefix in trisyllabic or longer copy.
- b. Delete onsetless syllable in trisyllabic or longer copy.

These truncation rules apply to a full copy of the Stem, including the root and any prefixes. The rules apply in transparent (i.e. feeding) order, a type of rule interaction permitted in this theory (Steriade 1988a:83). The following derivations show how these rules apply:

#### (6) Derivations in Full Copy Analysis

	a.	b.	c.
Full Copy	/noŋ-kawosi-noŋ-kawosi/	/osampi-osampi/	/n-osampi-n-osampi/
(5a)	noŋ-kawosi-kawosi		n-osampi-osampi
(5b)		osampi-sampi	n-osampi-sampi

For instance, rule (5a) applies to a full copy to yield *noŋ-kawosi-kawosi*, and rule (5b) applies to a full copy to yield *osampi-sampi*. Forms like *n-osampi-sampi* are derived by successively applying (5a) and then (5b) to the full copy input. Rules (5a) and (5b) correctly fail to apply with

<sup>71</sup>Spring (1990a) does not present an analysis of this reduplicative pattern.

<sup>72</sup>Other discussions of the Full Copy model include Hayes and Abad (1989), Mutaka and Hyman (1990), Davis (1990), Hammond (1990), and Bat-El (1992). An important insight of this approach, unrelated to the creation and reduction of the full copy, is the imposition of syllabic markedness conditions on the template. We take this up below in §7.

short copies like *no-naa-no-naa*, *n-asi-n-asi* or *asi//asi*, though obviously they cannot account for the fact that *asi//asi* is a compound.

Despite their empirical success, rules (5a) and (5b) have an obvious liability: both must mention the seemingly arbitrary condition “in a trisyllabic or longer Reduplicant”. The solution within this approach is to impose the constraint DISYLL as a kind of template, seeing it as an implicit condition on these rules:

(7) Full Copy Analysis (Second Version)

- a. Delete prefix in trisyllabic or longer copy.
- b. Delete onsetless syllable in trisyllabic or longer copy.

The assumption is that DISYLL blocks (7a) and (7b) from applying when the result would be monosyllabic. This is the normal function of templates in the Full-Copy approach.

But this explanatory improvement exacts an empirical cost, as the following derivation shows:

(8) Failed Derivation in Full Copy Analysis (7)

Full Copy	/n-asi-n-asi/
(7a)	*n-asi-asi
(7b)	Blocked by DISYLL

That is, the analysis now derives \**n-asi-asi* rather than *n-asi-n-asi*. The problem is that deletion of the prefix *n-* from the full copy /n-asi-n-asi/ does not change the syllable count, so it should not be blocked by DISYLL. That is, DISYLL, conceived of in this context as a constraint that blocks rules from applying, will only affect operations that delete vowels.

The solution to this new problem within the Full-Copy analysis is to impose the constraint ONSET on the truncation rules as well, so that rule (7a) is blocked from applying to *n-asi-n-asi*. (Imposition of a syllabic well-formedness condition like ONSET on the template is possible in Full-Copy theory — v. §7.) This analysis is successful empirically, but it has two serious theoretical problems. First, the account of *n-osampi-sampi* relies crucially on violating ONSET at an intermediate stage of the derivation, since rule (7a) must delete the prefix *n-* in order to create the onsetless syllable that rule (7b) then deletes:

(9) Derivational Complications in Full Copy Analysis (7)

Full Copy	/n-osampi-n-osampi/
(7a)	n-osampi-osampi ! violates ONSET
(7b)	n-osampi-sampi

Though the output obeys ONSET, the intermediate representation does not. Thus, ONSET must govern the output of the whole rule system rather than the output of each individual rule. This violation of a well-formedness constraint at intermediate stages of the derivation is a characteristic complication of systems that attempt to combine constraints with serial rule application (v. Myers 1991). Second, a new redundancy has been introduced, since the constraint ONSET prohibits onsetless syllables and rule (7b) deletes them. This redundancy (called the

“Duplication Problem” in Kenstowicz and Kisseberth 1977) is a familiar liability of approaches that seek to combine constraints and rules.

It should by now be clear that any satisfactory account of Axininca Campa reduplication within the Full-Copy approach must call on essentially the same well-formedness constraints as the Optimality-Theoretic analysis we have presented here. But Full-Copy theory also has an eponymous commitment to making a full copy of the Base and then subjecting it to various truncation rules. The obvious solution to the redundancies and derivational complications we have noted is to dispense with the full copy, the truncation rules, and the derivation. What’s left, then, is reduplication purely by constraint satisfaction or, in brief, Optimality Theory.

## 7. Prosody >> Morphology: Constraint Interaction in Prosodic Morphology

### 7.1 Introduction

The theory of Prosodic Morphology (McCarthy and Prince 1986 *et seq.*) is fundamentally a view of how prosodic and morphological well-formedness requirements interact with one another. It is embodied in three core principles:

#### (1) Standard Prosodic Morphology

##### a. Prosodic Morphology Hypothesis<sup>73</sup>

Templates are defined in terms of the authentic units of prosody: mora ( $\mu$ ), syllable ( $\sigma$ ), foot (Ft), prosodic word (PrWd).

##### b. Template Satisfaction Condition

Satisfaction of templatic constraints is obligatory and is determined by the principles of prosody, both universal and language-specific.

##### c. Prosodic Circumscription

The domain to which morphological operations apply may be circumscribed by prosodic criteria as well as by the more familiar morphological ones.

The Prosodic Morphology Hypothesis and the Template Satisfaction Condition together demand that templatic morphology conform to the universal theory of prosody and to the grammar of prosody in some specific language. The principle of Prosodic Circumscription imposes a similar requirement on circumscriptional morphology. The essence of (1) is that templatic and circumscriptional morphology are governed by universal and language-particular constraints on prosodic well-formedness.

Optimality Theory offers a new perspective on the principles of Prosodic Morphology. Specifically, the second clause of the Template Satisfaction condition (“Satisfaction of templatic constraints ... is determined by the principles of prosody, both universal and language-specific”) and Prosodic Circumscription can be seen as fixing a dominance relation between the well-formedness requirements of two different domains, prosody (**P**) and morphology (**M**): **P** >> **M**. That is, in templatic and circumscriptional morphology, the constraints on prosodic structure — such as ONSET — take precedence over the constraints on morphological structure — such as MAX.

Certain other aspects of Optimality Theory, especially the developments introduced in this work, also lead to a very different conception of templates and the Template Satisfaction Condition. Templates, it will emerge, are a particular kind of constraint of the large ALIGN family, asserting the coincidence of morphological and prosodic constituents or their edges. Templates, then, are constraints on the prosody/morphology interface, and from this the Prosodic Morphology Hypothesis follows as a necessary consequence. Moreover, like the other ALIGN constraints or indeed constraints of all types, templatic constraints are violable in principle. Though in many familiar cases templatic constraints are undominated, in others, as we will see, templatic constraints may be violated under the compulsion of dominant constraints.

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<sup>73</sup>Earlier proposals for a specific role for prosody in templatic morphology include McCarthy (1979a), Marantz (1982), Levin (1983), McCarthy (1984), and Lowenstamm and Kaye (1986).

This new understanding of the theory of Prosodic Morphology, achieved with the help of Optimality Theory, is embodied in the following principles:

(2) Prosodic Morphology within Optimality Theory

a. Prosodic Morphology Hypothesis

Templates are constraints on the prosody/morphology interface, asserting the coincidence of morphological and prosodic constituents.

b. Template Satisfaction Condition

Templatic constraints may be undominated, in which case they are satisfied fully, are they may be dominated, in which case they are violated minimally, in accordance with general principles of Optimality Theory.

c. Ranking Schema

**P**  $\gg$  **M**

By reexamining some classic cases of templatic and circumscriptional morphology, we will show that the schema **P**  $\gg$  **M** captures and extends the insights of standard Prosodic Morphology (§7.2). The schema encompasses, for example, the proposal of Steriade (1988a) that Prosodic Morphology should have access to principles of syllabic markedness as well as to templatic conditions of the familiar sort. But, unlike the theses of standard Prosodic Morphology (1), the scope of **P**  $\gg$  **M** is not limited to these cases. This schema is a broad assertion about the nature of prosodic morphology: if some morphological domain is to be prosodically conditioned, then in that domain **P** must dominate **M**. This assertion holds for *any* type of morphology, not just template satisfaction and prosodic circumscription. It therefore provides a general characterization of how prosody impinges on morphology, one that intrinsically relies on the Optimality-Theoretic conception of constraint domination and violation. Below (§7.3) we will apply this result to two types of phenomena that are well outside the purview of standard Prosodic Morphology, non-circumscriptional infixation and non-templatic reduplication. We will also see, using Axininca Campa as our focus, how a rich system of constraints is packaged into ranked blocks by the **P**  $\gg$  **M** schema.

The concluding section (§7.4) examines the status of templates and template satisfaction, picking up themes that are introduced in the analyses of the earlier sections. We will show that templates are indeed alignment constraints, and we will discuss cases where templatic constraints are violated. This development reduces the theory of Prosodic Morphology to the **P**  $\gg$  **M** schema and a set of constraints, all violable in principle, on the alignment of morphological and prosodic categories.

## 7.2 Standard Prosodic Morphology Revisited

The Ilokano plural prefix in (3) is a familiar example of templatic reduplication, in which the template is a heavy syllable:

## (3) Ilokano Reduplication (McCarthy and Prince 1986, 1991b, Hayes and Abad 1989)

a. /CVC~/ Roots<sup>74</sup>

kaldín	‘goat’	<u>kal</u> -kaldín	‘goats’
púsa	‘cat’	<u>pus</u> -púsa	‘cats’
kláse	‘class’	<u>klas</u> -kláse	‘classes’
jyánitor	‘janitor’	<u>jyan</u> -jyánitor	‘janitors’

## b. /CVʔ~/ Roots

kaʔót	‘s.t. grabbed’	<u>ka</u> :-kaʔót	‘id. (pl.)’
róʔot	‘leaves, litter’	<u>ro</u> :-róʔot	‘id. (pl.)’

Descriptively, the Reduplicant consists of the maximal initial string of the base that can be parsed as a heavy syllable. When the initial string of the base cannot supply a heavy syllable directly — as in (3b), since ʔ cannot close a syllable in Ilokano — the vowel of the Reduplicant is lengthened.

One factor operative in (3) is the heavy-syllable template  $\sigma_{\mu\mu}$ , an unviolated constant of shape that unites all of the various realizations of the Ilokano plural. The satisfaction of  $\sigma_{\mu\mu}$  is governed by constraints from the **M** and **P** domains. The **M**-constraint on template satisfaction is MAX (8), which demands exactness of copying. For example, MAX selects the Reduplicant *jyan* over less exact candidates like \**jya*: or \**ji*:. The various **P**-constraints specify what a possible heavy syllable is. For example, a never-violated universal **P**-constraint asserts that  $[jyan]_{\sigma}$  is a possible heavy syllable but \* $[jyani]_{\sigma}$  is not;<sup>75</sup> another **P**-constraint, undominated in Ilokano, determines that \* $[roʔ]_{\sigma}$  is not a possible heavy syllable.

For morphology to be prosodic at all within Optimality Theory, the ranking schema **P**  $\gg$  **M** must be obeyed weakly, in that *some* phonological constraint must dominate some constraint of the morphology. Thus, the **P**-constraints take precedence over the **M**-constraint MAX, so adherence to the requirements of prosody supersedes exactness of copying. Though the reduplicant \**jyani* is more exact than *jyan*, only the latter conforms to the universal prosodic requirements on what a heavy syllable can be. Similarly, though the reduplicant \**roʔ* is more exact than *ro*:, only the latter conforms to the Ilokano-specific requirements on what a heavy syllable can be. A stronger interpretation of the schema **P**  $\gg$  **M**, whereby all phonological constraints are dominant, exactly captures the effects of the second clause of the original Template Satisfaction Condition: “Satisfaction of templatic constraints ... is determined by the principles of prosody, both universal and language-specific.”

<sup>74</sup>Monosyllables reduplicate in an unexpected way:

trák	‘truck’	tra:-trák	‘trucks’
nárs	‘nurse’	na:-nárs	‘nurses’.

<sup>75</sup>If a constraint is never violated, it is essentially part of the basic definition of a structural category and one might as well regard it as part of Gen rather than part of the harmony-evaluation system.

Prosodic Circumscription of Domains can also be subsumed under the **P**  $\gg$  **M** schema. Consider another example, this time the formation of the possessive in Ulwa, a language of the Atlantic coast of Nicaragua analyzed by Hale and Lacayo Blanco (1989). (Bromberger and Halle (1988) brought this example to our attention.) The possessive in Ulwa is marked by a set of infixes located after the first or second syllable of the noun:

(4) Ulwa Possessive Forms

su:lu	‘dog’
su:–ki–lu	‘my dog’
su:–ma–lu	‘thy dog’
su:–ka–lu	‘his/her dog’
su:–ni–lu	‘our (incl.) dog’
su:–kina–lu	‘our (excl.) dog’
su:–mana–lu	‘your dog’
su:–kana–lu	‘their dog’

The generalization is that the possessive infix follows the initial syllable if it is heavy (all monosyllables are heavy), otherwise it follows the peninitial syllable:

(5) Location of Ulwa Infixes (noun + ‘his’)

a. After Initial Syllable

bas	bas–ka	‘hair’
ki:	ki:–ka	‘stone’
su:lu	su:–ka–lu	‘dog’
asna	as–ka–na	‘clothes’

b. After Peninitial Syllable

sana	sana–ka	‘deer’
amak	amak–ka	‘bee’
sapa:	sapa:–ka	‘forehead’
siwanak	siwa–ka–nak	‘root’
kululuk	kulu–ka–luk	‘woodpecker’
ana:la:ka	ana:–ka–la:ka	‘chin’
arakbus	arak–ka–bus	‘gun’ (< harquebus?)
karasmak	karas–ka–mak	‘knee’

Stress in Ulwa falls on the first syllable if heavy, otherwise the second syllable, except that final syllables are unstressed (K. Hale, p.c.), indicating that the pattern is fundamentally left-to-right iambic. Below in the Appendix we present an analysis of the stress system of Axininca Campa, which is identical in all relevant respects to Ulwa. For present purposes, it is sufficient to observe that the sequence preceding –ka– in (5) is just exactly a single iambic foot.

The Ulwa phenomenon has been analyzed as *positive prosodic circumscription* (McCarthy and Prince 1990a: 225-243; cf. Broselow and McCarthy 1983, Aronoff 1988). The possessive infixes are actually suffixes on a prosodically delimited base, the initial foot. Formally, the morphology of the Ulwa possessive is analyzed as  $O:\Phi(\text{Ft, Left})$ , where  $O$  is the morphological operation “Suffix *ka, ki, ma, etc.*” and  $\Phi(\text{Ft, Left})$  is a function that returns the

leftmost foot of the word. As (6) shows schematically, the  $\Phi$ -delimited portion of the word serves as the Base to which suffixation of *-ka-* applies:

(6) Prosodic Circumscription in Ulwa Possessive (McCarthy and Prince 1990a)

Input	(siwá)nak
Circumscriptional Analysis	siwá⟨nak⟩
Suffix <i>ka</i> under PC	siwá-ka⟨nak⟩
Output	siwákanak

In (6), the ⟨ ⟩ brackets obscure the portion outside the  $\Phi$ -delimited Base. Parentheses indicate foot structure.

This conception of prosodic circumscription is formalized on the assumption that morphology consists of operations ('suffix morpheme M'), but Optimality Theory is framed in terms of constraints on structures rather than in terms of putative operations building them. Where prosodic circumscription theory provides a way of controlling the *input* to morphological and phonological processes, Optimality Theory wants a way to examine and evaluate the output structures. In fact we already have it in hand, in the notion of *Base* which is necessary to the statement of SFX-TO-PRWD and the copying constraints of reduplication theory (§§4.3, 5.2)

In §5.2, the *Base* was defined along these lines:

(7) Base

The Base of a suffixed morpheme is the phonological string preceding the exponent of that morpheme, up to the nearest initial edge [ of a PrWd.

The Base of a prefixed morpheme is the phonological string following the exponent of that morpheme, up to the nearest final edge ] of a PrWd.

As in the formulation of SFX-TO-PRWD, the specification of a prosodic Base is really an assertion about the prosody/morphology interface. Just like standard Prosodic Morphology, the definition (7) treats the Base as a category of analysis in the **P**-domain, equivalent to the familiar **M**-domain categories root, stem, and so on.<sup>76</sup> The key difference is that in Optimality Theory the category of analysis in the **P**-domain must be located in the output rather than in the input. Below we will show that alignment constraints like SFX-TO-PRWD, which crucially call on an *output* category of analysis, the Base, stake out much of the same empirical turf as prosodic circumscription theory.

Stated in these terms, the Ulwa constraint can be put like this:

(8) AFX-TO-Ft (Ulwa)

Base of 'possessive' is Foot.

The Base could also be usefully conceived of as a *minimal* PrWd, since all such interface constraints would then be limited to mention of the PrWd category (McCarthy and Prince 1991a,

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<sup>76</sup>This approach recalls the alternative account of prosodic circumscription in terms of domains proposed by McCarthy and Prince (1990a:243-4).

1991b). The theory must avoid the impossibility of affixing to *syllable* or to *mora*, legitimate prosodic categories but impossible Bases and PrWd's. To simplify the discussion, we will retain the direct formulation of AFX-TO-FT.

Since the possessive is a suffix, its Base, by definition (7), is the phonological material that immediately precedes its exponent. Therefore, if a form is to satisfy AFX-TO-FT, what precedes the left edge of the possessive morpheme must be a foot — *no more and no less* — as the following examples show:

(9) AFX-TO-FT Applied

<i>Obey</i> AFX-TO-FT	<i>Violate</i> AFX-TO-FT
[[ (bas) ]]-ka	[[ (su:) lu ]]-ka
[[ (amak) ]]-ka	[[ (siwa) (nak) ]]-ka
[[ (sana) ]]-ka	[[ (ana:) (la:) ka ]]-ka

The Base (delimited by  $\llbracket \rrbracket$ ) extends from the left edge of the possessive suffix *-ka* backward to the edge of the word (PrWd). To satisfy AFX-TO-FT, the Base must be exactly coextensive with a Foot, as it is in the examples on the left. The forms on the right, in which *-ka* is wrongly suffixed rather than infixes, all have Bases larger than a single Foot.

The possessive morphemes of Ulwa are also suffixes, and like all suffixes they are subject to the general constraint RIGHTMOSTNESS (v. §2 above and §7.3 below), which requires that suffixes fall at the right edge of the stem. Thus, unattenuated RIGHTMOSTNESS demands pure suffixation, as in *\*siwanak-ka*.

It is the *interaction* between RIGHTMOSTNESS and AFX-TO-FT that yields the observed pattern of suffixation to the foot. RIGHTMOSTNESS is a true **M**-constraint, one that characterizes the relation between a morphological entity, a suffix, and another morphological entity, a stem. But AFX-TO-FT is a **P**-constraint, because it crucially refers to a prosodic notion, the foot, as well as to a morphological one, the category 'possessive'. In accordance with the **P** >> **M** ranking schema, AFX-TO-FT dominates RIGHTMOSTNESS. Thus, the Ulwa possessive morpheme will appear as far to the right as possible, but it must in any case lie at an edge of the initial foot.

The following tableau shows the more harmonic candidates for the /-ka/ possessive of *(siwa)nak*:

(10) AFX-TO-FT/RIGHTMOSTNESS Interaction

Candidates	AFX-TO-FT	RIGHTMOSTNESS
a. $\llbracket (siwa)nak \rrbracket -ka$	* !	
b.  $\llbracket (siwa) \rrbracket -ka -nak$		nak

RIGHTMOSTNESS is interpreted gradiently, so degrees of departure from perfection are shown in the tableau by the size of the string separating /-ka/ from the end of the word. In (10a), the Base is not a Foot — it is something more — so dominant AFX-TO-FT is violated. Of course, if RIGHTMOSTNESS were dominant, then (10a) would be the output — simple suffixation, in which

prosodic factors are inert. In (10b), the Base is a Foot, and RIGHTMOSTNESS is satisfied only as much as it can be; this form is therefore optimal.<sup>77</sup>

If LEFTMOSTNESS rather than RIGHTMOSTNESS is in force, the exactly symmetrical pattern of *prefixation* to a prosodic Base is obtained. This is the case in Samoan plural reduplication (Marantz 1982, Broselow and McCarthy 1983, McCarthy and Prince 1986, 1990a, 1991b, Levelt 1990):

(11) Samoan Plural Reduplication (Marsack 1962)

táa	<u>ta</u> -taa	‘strike’
nófo	<u>no</u> -nofo	‘sit’
alófa	a- <u>lo</u> -lofa	‘love’
?alága	?a- <u>la</u> -laga	‘shout’
fanáu	fa- <u>na</u> -nau	‘be born, give birth’
maná?o	ma- <u>na</u> -na?o	‘desire’

The underscored Reduplicant is a copy of the initial mora of the stress foot, a trochee in Samoan. Thus, the plural morpheme is  $\sigma_\mu$ , affixed to a prosodic Base in satisfaction of dominant AFX-TO-FT. It is a *prefix* to the prosodic Base in accordance with LEFTMOSTNESS. As required by the copying constraints (§5.2), the Reduplicant is an ANCHORED, CONTIGUOUS substring of the Base, MAXimally satisfied subject to the templatic  $\sigma_\mu$  limit.

These analyses of Ulwa and Samoan illustrate a general approach to infixation via positive prosodic circumscription within Optimality Theory. On one side there is a **P**-constraint defining the prosodic Base, e.g. AFX-TO-FT. Like ALIGN or SFX-TO-PRWD, it is a constraint on the prosody/morphology interface, demanding that the affix be preceded or followed by a phonological string of a particular type. On the other side there is an **M**-constraint, either RIGHTMOSTNESS or LEFTMOSTNESS, that characterizes normal suffixing or prefixing behavior. Whenever affixation is prosodically determined, the interaction between these two competing requirements is set by **P**  $\gg$  **M**. Indeed, in such cases the ranking follows the logic of constraint domination, as expressed in Pānini’s Theorem (Prince and Smolensky 1993: §7 and §5.2 above): to be visibly active, the more specific **P**-constraint must dominate the general **M**-constraint. Thus, RIGHTMOSTNESS or LEFTMOSTNESS is obeyed only contingently, subject to a superordinate demand on the prosody of the Base. The concept is fundamentally similar to prosodic circumscription in that a notion of *Base* of affixation is defined in prosodic as well as morphological terms, fundamentally different in that the *Base* is delimited on the candidate forms rather than the input.

Some interesting issues remain. In Yidiñ reduplication, the Base is the the initial foot of the word, and all words begin exactly with a foot (Nash 1979, 1980:144; McCarthy and Prince 1990a:232-234). Because the Reduplicant is prefixal, the circumscription requirement does not affect the *location* of the Reduplicant, but rather what material it can copy. For this, it is crucial where the first foot ends, not where it begins. A typical example is the contrast between *mula-(mula)ri* and *\*mular-(mula)ri* ‘initiated man’. The failed candidate is syllabically well-formed and more MAXimal, yet it is suboptimal because in it the Reduplicant draws melody from

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<sup>77</sup>In some cases, it may be necessary to designate the main-stressed foot as the Base, if XMOSTNESS alone is not sufficient to determine which foot serves as the Base.

beyond the first foot. This pattern cannot be understood in terms of AFX-TO-FT, which demands that the whole string from the edge of the affix to the end of the word must be exactly a foot — obviously not the case here. However, if the principle of formation is ‘affix to minimal PrWd’, then the result can be achieved by parsing the root with internal recursive PrWd structure: mula-[[mula] ri]. This is entirely consistent with the surface prosody of the language. The Base here will be [mula], as desired, by the definition given in (7), which bounds the Base string by the category PrWd. (In addition, it may also be useful to distinguish the notion of Base in a compound-like structure, as in Yidiñ or Axininca *asi//asi* (§5.4), from the way *Base* is interpreted in internal affixation.)

More challenging are the thoroughly nonconcatentive cases like the Arabic broken plural and diminutive or the Cupeño habitative (McCarthy and Prince 1990a, Crowhurst 1993), where the prosodically circumscribed Base provides the input material for a templatic formation that completely replaces the original Base. Dealing with this requires extending the faithfulness principles to handle nonmonotonic re-analysis as well as simple primary analysis, a matter for future research.<sup>78</sup>

As conceived in McCarthy and Prince (1990a), the theory of Prosodic Circumscription recognizes a second type of relation between the prosodic Base and the operation applied to it. Partial-mode prosodic circumscription, or *prosodic delimitation*, defines a morphological operation only over a prosodically-specified subset of the lexicon, demanding the coincidence of Foot and Base as a precondition for rule application. Some examples:

(i) In English, comparative and superlative *-er* and *-est* are used on one-foot adjectives:

bigger  
stupider  
happier

Longer adjectives default to periphrasis:

?intenser/more intense  
\*auguster/more august  
\*intelligenter/more intelligent

(ii) In Maori (Hohepa 1967:19), the imperative is marked by *ee-* only in bimoraic verbs:

ee tuu ‘stand up!’  
ee noho ‘sit down’  
ee kai ‘eat!’

In longer verbs, the imperative is not marked morphologically:

haere ‘go!’  
patu-a ‘hit/kill (him)!’  
faka-oma-tia ‘make (it) run!’

(iii) In Kinande (Mutaka and Hyman 1990), trisyllabic nouns simply do not reduplicate; in the Northern Karanga dialect of Shona, trisyllabic stems reduplicate postlexically, showing different tonology from the canonical disyllabic forms (Hewitt and Prince 1989; cf. Odden 1981, Myers 1987).

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<sup>78</sup>Another sort of challenge is presented by cases that seem to require *composition* of prosodic circumscription, including Cupeño, Choctaw (Lombardi and McCarthy 1991), and Korean (Lee and Davis 1993; cf. Kim 1984).

(iv) In Mezquital Otomi:

“The three suffixes, though not parallel grammatically, form a phonological paradigm. Monosyllabic allomorphs [*-ki, -ʔi, -bi*] occur with disyllabic stems, disyllabic allomorphs [*-kaki, -ʔaʔi, -babi*] occur with monosyllabic stems... Thus the allomorphic gamut ... provides various phonological crutches to preserve or supplement rhythm.” (Wallis 1964:79)

Cf. Mester (to appear).

(v) In Dyirbal (Dixon 1972:42, 288-9), the ergative suffix is *-ŋgu* with disyllabic V-final nouns:

yaʔa-ŋgu                    ‘man’

But the ergative is *-gu* with longer V-final nouns:

yamani-gu                    ‘rainbow’

balagara-gu                    ‘they’

In Dyirbal, for example, stress is trochaic, falling on the initial syllable and every second syllable thereafter. So disyllabic nouns are exactly one foot long, and monopodicity (or minimality — v. §4.3) is the criterion that segregates the *-ŋgu*-class from the default *-gu*-class.

McCarthy and Prince (1990a) propose that the morphological Base (call it  $B_M$ ) must be identical to the prosodic Base (which we have been calling simply the Base,  $B$ ) in order for the prosodically delimited morphological operation to succeed. To put it differently, the parsing function  $\Phi$ , when applied to the morphological Base  $B_M$ , must return a prosodic Base  $B$  that is identical to the morphological Base. This special sense of  $\Phi$ , designated  $\Phi'$ , is a partial function defined as in (12):

(12) Definition of Partial Function  $\Phi'$

$$\Phi'(B_M) = B \quad \text{if } B_M = \Phi(B_M) \\ \text{else, undefined.}$$

The prosodically restricted operation  $O:\Phi'$  depends on the success of the function  $\Phi'$ , and  $O:\Phi'$  is therefore undefined when  $\Phi'$  is. An operation applying under  $\Phi'$  applies only to words that exactly satisfy the prosodic criterion  $\Phi'$ , typically monopodicity or, equivalently, minimality.

The Dyirbal ergative, for example, consists of two morphological operations. One is “Suffix *-ŋgu*”, restricted prosodically by  $\Phi'$ (Ft). The other is prosodically unrestricted “Suffix *-gu*”, whose scope is limited only by the Elsewhere Condition. If  $\Phi'$  returns a value, in accordance with (12), then *-ŋgu* is suffixed, since the target form is a monopod. But if  $\Phi'$  returns no value at all, then “Suffix *-ŋgu*” cannot apply, and the default suffix *-gu* is provided instead. In general, a default operation needn’t be specified; as examples (i)-(v) above show, the responses to blocking of the prosodically delimited morphological operation are quite diverse, ranging from complete failure (Kinande) to zero affixation (Maori) to syntactic periphrasis (English). Such matters are outside the purview of Prosodic Circumscription theory (and perhaps of linguistic theory more generally, to the extent that they reflect functional rather than formal factors).

This basic insight carries over into Optimality Theory, but with an interesting twist. As with the  $\Phi$ -circumscribed Ulwa possessive, the  $\Phi'$ -delimited ergative of Dyirbal is subject to a constraint on the alignment of morphological and prosodic categories. The suffix *-ŋgu* obeys

AFX-TO-FT, formulated exactly as in (8) above. This constraint requires that the Base — the phonological string preceding *-ŋgu* — be exactly a foot. Because it is a suffix, *-ŋgu* is also subject to RIGHTMOSTNESS.

Consider now how these constraints apply to the obvious candidates containing the suffix *-ŋgu*:

(13) Performance of *-ŋgu* Candidates

<i>Size</i>	<i>Example</i>	AFX-TO-FT	RIGHTMOSTNESS
2-σ	[[yáʔa]]-ŋgu	✓	✓
3-σ	*[[yáma] ni]-ŋgu	*	✓
	*[[yáma]]-ŋgu-ni	✓	*
4-σ	*[[bála] (gára)]-ŋgu	*	✓
	*[[bála]]-ŋgu- (gára)	✓	*

The disyllabic case is unremarkable. The problem is with the polysyllables: ranking the constraints either way will give the wrong output: either the Base to which *-ŋgu* is suffixed is more than a foot, or else *-ŋgu* is non-final. The choice is between the Scylla of *-ŋgu*-suffixation everywhere, rendering AFX-TO-FT invisible, and the Charybdis of *-ŋgu*-infixation, essentially as in Ulwa. The issue, obviously, is how to force *no output at all* in preference to a less-than-perfect output, within a theory where every input is assigned some output.

The solution is to make the functional equivalent of *no output* a member of the candidate set and to rank the constraint prohibiting it below AFX-TO-FT and RIGHTMOSTNESS. This approach is developed by Prince and Smolensky (1993: §4.3.4), who observe that the *Null Parse*, which supplies no analysis to the input, is uniquely unsuited to participate in linguistic structure. The idea is that, among the candidate output forms, there is one in which the affix is simply not joined with the base at all; the output form remains morphologically unparsed, identical to the input. Such an output is fatally flawed, because it cannot play any role in the syntax or higher morphology: unless an input {A, B} is analyzed structurally as [A B]<sub>Cat</sub>, nothing that refers to *Cat* can deal with it. Intuitively, the productivity of *-ŋgu* — where “productivity” refers to the extension of this affix over the entire nominal lexicon — is subordinated to the interface requirement AFX-TO-FT and the linear ordering constraint RIGHTMOSTNESS. This possibility will emerge if the identity transformation is part of Gen, so the input {A, B} has, among its output candidates, the Null Parse {A, B}.

In order to allow prosodic constraints to control the placement and productivity of affixes, we assume that input representations consist of a set of formatives unspecified for their morphological organization or even linear order:

(14) Input Representations — Dyirbal

- a. {*ŋgu*, *yaʔa*}
- b. {*ŋgu*, *yamani*}
- c. {*ŋgu*, *balagara*}

The candidate set will contain a totally faithful and therefore morphologically-uninterpreted replicant of the input as well as the more articulated structures in which the root and affix are appropriately parsed into a stem:

(15) Some Candidate *Output* Representations — Dyirbal

- a.  $\{\eta gu, ya\{a\}\}, |ya\{a\}-ngu|_{Stem}$
- b.  $\{\eta gu, yamani\}, |yamani-\eta gu|_{Stem}, |yama-\eta gu-ni|_{Stem}$
- c.  $\{\eta gu, balagara\}, |balagara-\eta gu|_{Stem}, |bala-\eta gu-gara|_{Stem}$

The Null Parse is identical to the input, a useless result that the grammar cannot process further. Whenever the Null Parse is optimal, there is no functional output form. Alternative formational patterns, as in (i)-(v) above, must be followed.

The Null Parse is often avoided, since it is a common condition of productive morphology to succeed over the entire lexicon. Therefore, the following constraint is often undominated:

(16) M-PARSE

Morphemes are parsed into morphological constituents.

M-PARSE is typically dominated, à la Pāṇini's Theorem, by specific requirements on morphemic combination. For example, an input like  $\{think, ation\}$  must remain unparsed due to the requirement that the affix *-ation* attach only to Latinate stems. In prosodic morphology, where  $\mathbf{P} \gg \mathbf{M}$  applies, a similar effect can arise from purely phonological considerations.

M-PARSE is crucially dominated in Dyirbal, as the following tableau shows:

(17) Input  $\{\eta gu, ya\{a\}\}$ , Output  $|ya\{a\}-ngu|_{Stem}$

Candidates	AFX-TO-FT	RIGHTMOSTNESS	M-PARSE
a. $\{\eta gu, ya\{a\}\}$			* !
b. $\{\eta gu, ya\{a\}\} \rightarrow  ya\{a\}-ngu $			

Here the Null Parse ties with the optimal candidate (b) on the interface and affix-location constraints, which it satisfies vacuously by virtue of having no affixal relation defined. But it fails on M-PARSE.

(18) Input {*ŋgu, yamani*}, Output {*ŋgu, yamani*} (= Null Parse)

Candidates	AFX-TO-FT	RIGHTMOSTNESS	M-PARSE
a. $\{ \text{ŋgu, yamani} \}$			*
b.  yamani-ŋgu	* !		
c.  yama-ŋgu-ni		* !	

Here the competition faced by the Null Parse is much weaker. Any morphologically parsed candidate fails AFX-TO-FT or RIGHTMOSTNESS, as it must when the root is longer than a single foot. Since the Null Parse is successful (again vacuously) on both of these superordinate constraints, these failures are fatal and the Null Parse emerges as the optimal candidate.

In this way an Optimality-Theoretic account of prosodic Base delimitation emerges, and indeed, with  $\mathbf{P} \gg \mathbf{M}$ , it is possible to reconstruct the Base-specification typology of standard Prosodic Circumscription theory. This new typology is laid out in the following table:

(19) New Typology of Positive Circumscription and Delimitation

a.  $\mathbf{M} \gg \mathbf{P}$

XMOSTNESS, M-PARSE  $\gg$  AFX-TO-FT

Non-prosodic morphology (ordinary affixation)

b.  $\mathbf{P} \gg \mathbf{M}$ , XMOSTNESS crucially dominated

AFX-TO-FT, M-PARSE  $\gg$  XMOSTNESS

Positive prosodic circumscription (Ulwa possessive)

c.  $\mathbf{P} \gg \mathbf{M}$ , M-PARSE crucially dominated

AFX-TO-FT, XMOSTNESS  $\gg$  M-PARSE

Prosodic delimitation (Dyirbal ergative)

The critical typological distinction is made by ranking one of the three constraints at the bottom of the hierarchy. (The ranking of the other two has no discernible consequences.) If the  $\mathbf{P}$ -constraint AFX-TO-FT is ranked below the  $\mathbf{M}$ -constraints, it has no visible effects, and so the morphology is not under prosodic control. This is the case with ordinary affixation. If, on the other hand, an  $\mathbf{M}$ -constraint is ranked below a  $\mathbf{P}$ -constraint, we have a case of prosodic morphology, as  $\mathbf{P} \gg \mathbf{M}$  entails. If the low-ranking  $\mathbf{M}$ -constraint is a linear-order requirement - LEFTMOSTNESS or RIGHTMOSTNESS — the grammar characterizes a system with affixation to a prosodically circumscribed constituent. If the low-ranking  $\mathbf{M}$ -constraint is M-PARSE, the result is morphology whose very productivity is prosodically controlled. It is striking that the standard typology is so readily reconstructible and that all permutations of the ranking correspond to real linguistic systems.

In Prosodic Circumscription theory, the Base can also be defined negatively, as the residue after a designated constituent has been removed from consideration. For example, reduplicative infixation in Mangarayi (Merlan 1982:213-6; McCarthy and Prince 1986, 1991b; Davis 1988a:319-22) prefixes a  $\sigma$  template to a Base consisting of the word minus its initial consonant:

## (20) Mangarayi Plural Reduplication

Singular	Plural	
baraŋali	b- <u>ar</u> -araŋali	‘father-in-law’
gabuji	g- <u>ab</u> -abuji	‘old person’
yirag	y- <u>ir</u> -irag	‘father’
jimgan	j- <u>img</u> -imgan	‘knowledgeable person’
gambuṛa	g- <u>amb</u> -ambuṛa	‘classificatory MB/ZC’
muyg-ji	m- <u>uygj</u> -uyg-ji	‘having a dog’

This phenomenon is standardly analyzed as  $O/\Phi(C, \text{Left})$ , where  $O$  = “Prefix  $\sigma$ ” — that is, negative circumscription of an initial consonant. In this way, the Base to which  $\sigma$  is prefixed and which it copies is the word minus its initial consonant:

## (21) Prosodic Circumscription in Mangarayi Plural

Input	jimgan
Negative PC Analysis	$\langle j \rangle$ imgan
Prefix $\sigma$ and Copy, under PC	$\langle j \rangle$ <u>img</u> -imgan
Output	jimgimgan

Within Optimality Theory, where the *output* configuration must be specified, the locus of RED in the Mangarayi plural can also be specified by requiring the alignment of edges of prosodic and morphological categories. In this case, though, the relevant morphological constituent is the Root, not the affix:

## (22) ROOT-ALIGN (Mangarayi)

Left edge of Root coincides with left edge of PrWd.

That is, ROOT-ALIGN requires that the segment lying in PrWd-initial position be Root-initial as well. All Mangarayi roots are C-initial; thus, the issue of initial epenthesis, important with the similar constraint ALIGN-L of Axininca Campa, does not arise.

ROOT-ALIGN bars the Reduplicant in Mangarayi from word-initial position, since the Reduplicant, the exponent of the morpheme RED, is not part of the Root. But since the Reduplicant is a prefix, this constraint is in conflict with LEFTMOSTNESS. The locus of the Mangarayi plural affix *is* prosodically determined, so the ranking schema  $\mathbf{P} \gg \mathbf{M}$  is in play. It requires that the  $\mathbf{P}$ -constraint ROOT-ALIGN dominate LEFTMOSTNESS. Thus, the Reduplicant must fall as close as possible to the left edge of the PrWd yet still not align with it, as the following tableau shows:

(23) ROOT-ALIGN  $\gg$  LEFTMOSTNESS Ranking Argument

Candidates	ROOT-ALIGN	LEFTMOSTNESS
a. <u>jim</u> -[jimgan]	* !	
b. [j- <u>img</u> -imgan]		j
c. [jim- <u>gan</u> -gan]		jim !

The Mangarayi plural morpheme is a prefix, so the Base, for the purposes the copying constraints, is the part of the candidate form that follows the Reduplicant. The various candidate forms differ principally in the locus of the Reduplicant, and the difference in the Base follows from it. In (23a), the prefixed Reduplicant *jim* violates dominant ROOT-ALIGN, because RED, not the Root, is PrWd-initial. In (23b, c) the Reduplicant is non-initial, as required, so the selection is made by lower-ranking LEFTMOSTNESS. The pattern that emerges is one in which the Reduplicant is as close possible to initial position without actually being there, since initial position must be occupied by Root material.

Because Mangarayi infixation is reduplicative, another issue must also be addressed: the form of the reduplicative template. For some of the candidates contemplated in (23), the Reduplicant is exactly coextensive with a syllable: \**jim*-*jimgan*. But in the actual output form, the reduplicant is unaligned with the edges of syllables: *j-img-imgan*. Thus, if the templatic requirement in Mangarayi is RED= $\sigma$ , it must be among the *violable* constraints of this language, crucially ranked below ROOT-ALIGN and LEFTMOSTNESS, since it conflicts with both:

(24) ROOT-ALIGN  $\gg$  RED= $\sigma$ 

Candidates	ROOT-ALIGN	RED= $\sigma$
<u>jim</u> -jimgan	* !	
☞ j- <u>img</u> -imgan		*

(25) LEFTMOSTNESS  $\gg$  RED= $\sigma$ 

Candidates	LEFTMOSTNESS	RED= $\sigma$
jim- <u>gan</u> -gan	jim !	
☞ j- <u>img</u> -imgan		*

Because of the dominant constraints, the templatic target  $\sigma$  is met only weakly, though violation is still minimal, as usual in Optimality Theory. (Complex questions, yet to be addressed, underlie the characterization of *minimal* violation of a templatic target.) Here, then, we have established that templatic requirements are among the violable constraints of language, a result whose implications are explored more fully in §7.4.

Some examples of negative prosodic circumscription seem actually to have been misanalyzed in the past; two of these, Tagalog and Timugon Murut, are discussed below (§7.3). But there remains a body of cases, of which Mangarayi is one, where the locus of infixation can best be defined by constraints like ROOT-ALIGN. Probably the simplest imaginable example of this type is *ta*-infixation in Akkadian (McCarthy 1993), which forms passives and iteratives of verbs:

(26) Infixation in Akkadian (Examples based on hypothetical root  $\sqrt{pdk}$ )

Basic Verb	<i>ta</i> -Infixed Verb	
pu.d.dik	pu-.ta-d.dik	D Form (causative/factive)
šup.dik	šu-.ta-p.dik	Š Form (causative)
nap.dik	ni-.ta-p.dik <sup>79</sup>	N Form (passive)

The infix falls after the initial CV sequence of the stem, even if that is the middle of a syllable. In other words, the left edge of the stem (the “Basic Verb” in (26)) aligns with the left edge of PrWd, even in the *ta*-affixed form, as required by a constraint similar to ROOT-ALIGN. Below in (34)-(39) we will show how this pattern is derived through a combination of ROOT-ALIGN and syllabic requirements (ONSET), illustrating our analysis with the somewhat richer though basically similar system of Dakota.

### 7.3 Prosodic Morphology Without Circumscription or Templates

The discussion thus far has shown that the **P**  $\gg$  **M** ranking schema subsumes two central properties of the theory of Prosodic Morphology: the subordination of MAX to prosodic requirements in the Template Satisfaction Condition, and the subordination of the morphologic base to the prosodic base in Prosodic Circumscription of Domains. But **P**  $\gg$  **M** also does a great deal more, because it generalizes beyond templatic and circumscriptional morphology to prosodically-governed morphology that is neither templatic nor circumscriptional. One case of this type has been our focus throughout: the non-templatic system of reduplication in Axininca Campa. Another is a phenomenon we first introduced in §2, and that we will review in detail below: the non-circumscriptional system of infixation in Tagalog. To fully secure this result, we will also analyze a third example, infixing reduplication in Timugon Murut, which presents an important challenge to earlier conceptions of the theory of Prosodic Morphology. This section concludes with a review of the cross-linguistic treatment of vowel-initial forms in reduplication, revealing how the **P**-constraint ONSET can have diverse consequences depending on which **M**-constraint it dominates.

In classic Prosodic Morphology, Reduplication is non-templatic when the Reduplicant does not observe shape-invariance, since templates inherently demand shape-invariance. Therefore, total reduplication in all its forms — root, stem, or word — is non-templatic in the classic PM sense (McCarthy and Prince 1986, 1988). In total reduplication, the Reduplicant is simply an exact copy of the morphologically defined Base, as required by MAX. Reduplication

---

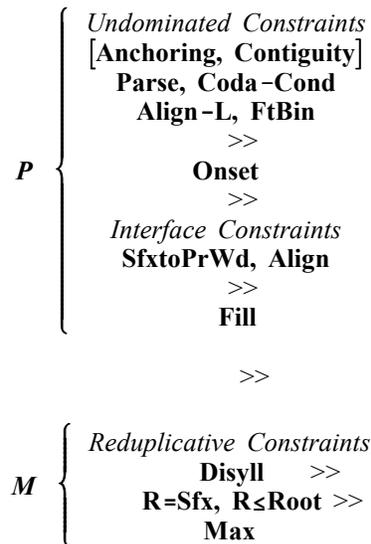
<sup>79</sup>In this form, the initial *n* is lost in the final output: *itapdik*.

in Axininca Campa is non-templatic in precisely this way: Axininca Campa has total root reduplication, with no fixed templatic target.<sup>80</sup>

This means, obviously, that the familiar Template Satisfaction Condition is not relevant to Axininca Campa reduplication. Yet the Optimality-Theoretic generalization of the Template Satisfaction Condition, the ranking schema  $\mathbf{P} \gg \mathbf{M}$ , not only applies to Axininca Campa reduplication but in fact serves as a fundamental organizing principle for the whole system.

To see this, consider the full Suffix-level constraint hierarchy of Axininca Campa, repeated here from §5.5:

(27) Axininca Campa Suffix-Level Constraint Hierarchy



Apart from the undominated constraints on the Reduplicant ANCHORING and CONTIGUITY, which are universally high-ranking (v. §5.2), the entire system is organized around the  $\mathbf{P} \gg \mathbf{M}$  relation, as the braces show. A block of  $\mathbf{M}$ -constraints pertaining to various characteristics of the Reduplicant — its minimal size, its status as a suffix, its morphological integrity, and its resemblance to the Base — are all ranked below the fundamental constraints on the prosodic structure of this language, the interface between prosodic and morphological structure, and faithfulness.

In this way, the reduplicative morphology of Axininca Campa is subject to prosodic requirements without the mediation of a template. Indeed, given the phonology of this particular language, the  $\mathbf{P} \gg \mathbf{M}$  schema imposes a phonologically invariant property on the Reduplicant that *could not be templatic*. Specifically, a suffixed (but not compounded) Reduplicant is consonant-initial, without exception. This characteristic of the Reduplicant is particularly noticeable when it leads to inexact copying, as in *osampi-sampi* (18) or *oiriŋkA-riŋkA* (25).

Under the Prosodic Morphology Hypothesis, it is impossible to require that the Reduplicant be consonant-initial *by a templatic specification alone*. Any template that named its initial element as a consonant would have to refer to the categories Consonant or Onset, but

<sup>80</sup>On the status of the quasi-templatic constraint DISYLL, see above §5.3 and below §7.4.

these are not prosodic units. The reduplicative system of Axininca Campa is in any case non-templatic; it imposes the requirement that the Reduplicant be consonant-initial indirectly, via the interaction of a variety of prosodic and morphological well-formedness conditions. While the **M**-constraint MAX demands exactness of copying, the dominant **P**-constraints ONSET, SFX-TO-PRWD, and FILL reject such exact-but-vowel-initial Reduplicants as *\*osampi<sup>T</sup>-osampi<sup>T</sup>*, *\*osampi-osampi*, and *\*oiriŋk-oiriŋk* in favor of inexact-but-consonant-initial *osampi-sampi* and *oiriŋkA-riŋkA*. (See §§5.2-5.3 for full explanation.) It is the dominance of **P** over **M**, rather than some property of a template, that ensures the consonant-initial invariance of the Axininca Campa Reduplicant.

Templatic reduplication in Ilokano and non-templatic reduplication in Axininca Campa share a common thread: the various **P**-constraints, by dominating the **M**-constraint MAX, demand conformity with the prosodic requirements of the language over exactness of copying. In the original conception of the theory of Prosodic Morphology, as in (1), this dominance of **P** over **M** is guaranteed only for *templatic* reduplicative morphology, via the Template Satisfaction Condition (1b). But the Optimality-Theoretic generalization of this relation, the schema **P**  $\gg$  **M**, applies equally well to *non-templatic* reduplication, as the analysis of Axininca Campa demonstrates. In this way, we achieve a new and broader perspective on a familiar principle of Prosodic Morphology.

Like the gross structure of constraint domination in Axininca Campa, the fine structure is also organized according to **P**  $\gg$  **M**. Thus, the purely phonological constraints on syllable structure dominate the constraints on the prosody/morphology interface:

- (28) ONSET  $\gg$  SFX-TO-PRWD  
 CODA-COND  $\gg$  ALIGN

These ranking relations are a matter of empirical necessity, as we argued in §4.2 and §4.3, since they are necessary to explain basic differences in the phonology of C-initial and V-initial suffixes. Abstractly, they show that the **P**-block distinguishes a sub-block  $\Phi$  of purely phonological constraints from a sub-block **I** of interface constraints, with the relation  $\Phi \gg \mathbf{I}$ . Similarly, within the block of reduplicative constraints, the constraint on the prosody of the Reduplicant, DISYLL, dominates constraints on its morphological status and integrity. This ranking too is required by the facts (v. (76) in §5.5). In both cases, the more purely prosodic constraints within a block are ranked above the more purely morphological ones. Like the overall structure of the Axininca Campa constraint hierarchy, this conforms to the basic dictum: if morphology is to be prosodic at all, then **P**  $\gg$  **M**.

Other details of the Axininca Campa constraint hierarchy can be rationalized in terms of Pānini's Theorem (Prince and Smolensky 1993; and §5.2, §7.2. here) and various other related points of generalized ranking logic. The lowest ranking member of the **P**-block is FILL, a very general constraint requiring that the output be faithful to the input representation by virtue of containing only structure that is motivated bottom-up by the input string. Any **P**-block constraint that can be satisfied by empty structure is crucially ranked above it. Likewise, the lowest ranking constraint in the **M**-block is MAX, which imposes the very general requirement on every Reduplicant that it be faithful to the Base that it copies. In both cases, a general constraint is ranked below a number of more specific ones. If the ranking were reversed, the more specific constraints would not be visibly active in the language.

A final example of **P**  $\gg$  **M** in reduplication, of particular interest because there are no alternative analyses consistent with our other assumptions about prosodic structure, comes from CV(:) reduplication in Nootka and Nitinaht (Stonham 1990, Shaw 1992). In these languages, there is reduplication of an initial CV sequence, transferring the length of the vowel:

(29) Nootka CV(:) Reduplication (Stonham 1990:19, 131)

- |    |                                      |                     |
|----|--------------------------------------|---------------------|
| a. | <u>ʔ</u> a-ʔawa-č <i>i</i> ʔ         | ‘naming one’        |
|    | <u>ʔ</u> u-ʔu-ʔi:h                   | ‘hunting it’        |
|    | <u>č</u> i-čims-ʔi:h                 | ‘hunting bear’      |
| b. | <u>wa</u> :~wa:s-č <i>i</i> ʔ        | ‘naming where...’   |
|    | <u>ta</u> :~ta:k <sup>w</sup> a-ʔi:h | ‘hunting only that’ |

The examples in (29a) show that the Reduplicant copies a short vowel as short, and examples (29b) show that the Reduplicant copies a long vowel as long. All forms show that the Reduplicant is an *open* syllable, an important feature of Stonham’s and Shaw’s proposals, which focus on the claim that syllables, and therefore templates, have a Nucleus constituent.

The template is clearly a syllable — as a constraint, RED= $\sigma$ . Under MAX, a  $\sigma$  template would be expected to lead to reduplications like \**čim-čims*~, but MAX is crucially dominated by NO-CODA, barring coda consonants from the Reduplicant.<sup>81</sup> The crucial interaction is NO-CODA  $\gg$  MAX:

(30) NO-CODA  $\gg$  MAX, in Nootka, from /RED-čims~/

Candidates	NO-CODA	MAX
a. <u>čim</u> -čims~	* !	s
c.  <u>či</u> -čims~		ms

Both candidates in (30) satisfy the templatic constraint RED= $\sigma$ ; they are differentiated by NO-CODA, which crucially dominates MAX. When the initial vowel is long, MAX will demand faithful copying of the long vowel as long (v. discussion of *transfer* in §5.2), and of course NO-CODA will not affect the faithful copying of a long vowel. The interaction here is a typical one: the **P**-constraint NO-CODA dominates the **M**-constraint MAX, allowing a phonological condition to determine the form of the reduplicant.

The dominance of **P**-constraints over **M**-constraints is also apparent in Prosodic Circumscription of Domains, as Ulwa shows. But the scope of **P**  $\gg$  **M** is not limited to prosodic circumscription; it provides a similarly broad perspective on infixation of all types, whether it is circumscriptional or not.

One particularly compelling example of non-circumscriptional infixation is the Tagalog morpheme *-um-*, which we first encountered in §2 above. This infix falls before the first vowel of a word:

<sup>81</sup>Steriade (1988a:80) may be suggesting something parallel to this. See Shaw (1992) for discussion.

(31) Tagalog *-um-* Infixation

Root	<i>-um-</i>	
/aral/	/um-aral/	‘teach’
sulat	s-um-ulat	‘write’
gradwet	gr-um-adwet	‘graduate’ (French 1988)

Though McCarthy and Prince (1990a) analyze Tagalog *-um-* circumscriptively, this account now seems deeply unsatisfactory.

Even simple observational adequacy is elusive. In theories that do not recognize Onset as a prosodic category (e.g. McCarthy and Prince 1986), it is impossible to characterize the circumscribed domain either positively or negatively, since neither pre-infixal *gr* nor post-infixal *adwet* is a prosodic constituent, at least (cf. Anderson 1991). There is a serious failure of principle as well. Circumscriptive accounts can only stipulate, and not explain, why words with initial clusters, all of them relatively recent loans, consistently behave like *gr-um-adwet* and never like *\*g-um-radwet* in Tagalog and other Austronesian languages. If Onset is admitted as a constituent, circumscription theory must offer a free choice between the various options for which unit is to be circumscribed (single consonant, or whole Onset). But there is no choice: it is never just the initial consonant, but always the maximal initial cluster.<sup>82</sup>

A further problem of principle is that specifying the locus of the infix by circumscription cannot explain why it is just exactly a VC-shaped affix that falls in prenuclear position. A prenuclear postconsonantal locus for a /VC/ affix makes eminent sense phonotactically, since it supports an unmarked CV syllable structure, as Anderson (1972) and Cohn (1992) point out. But neither they nor the circumscriptional account make this fundamental observation follow from the analysis.<sup>83</sup> Indeed, circumscription theory is designed to allow for complete independence between the shape of an affix and its mode of placement.

Clearly, then, *um*-infixation in Tagalog should not be analyzed by prosodic circumscription. Nonetheless, the locus of the infix is prosodically defined, since it responds to the prosodic well-formedness condition requiring open syllables. Prince and Smolensky’s (1991b, 1992, 1993) Optimality-Theoretic account, repeated from §2, determines the locus of *-um-* by the interaction of the **P**-constraint NO-CODA and the **M**-constraint LEFTMOSTNESS:

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<sup>82</sup>The Austroasiatic languages of Southeast Asia, such as Temiar and Kammu, seem to counterexemplify this claim. The counterexample evaporates, however, once the “sesquisyllabic” syllable structure of these languages is properly understood — see Sloan (1988), McCarthy and Prince (1991b) and cf. Anderson (1991).

<sup>83</sup>For example, Anderson’s account of the syllabic advantages of infixation is thorough and incisive, but the actual rule that the theory of the time allows him to propose is this:

$$+VC\#(C)V \\ 1\ 2\ 3\ 4\ 5\ 6 \Rightarrow 4(5)2\ 3\ 6$$

This is no more than a random choice from an immense space of permutations and deletions. Moravcsik (1977:141-2) presents an extended critique of Anderson’s analysis.

## (32) Tagalog Constraints

## a. NO-CODA

Syllables are open.

## b. LEFTMOSTNESS

Prefix is located at left edge of word.

The morpheme *-um-* is a prefix, hence subject to LEFTMOSTNESS. The constraint NO-CODA is also visibly in force, selecting open syllables over closed ones. Both constraints are universal, although in Tagalog as in many other languages, NO-CODA is ranked below the faithfulness constraints PARSE and FILL, since surface forms do contain fully-parsed closed syllables.

In the current context, what is of interest is the relation between these two constraints. Under  $\mathbf{P} \gg \mathbf{M}$ , the prosodic constraint NO-CODA dominates the morphological constraint LEFTMOSTNESS: NO-CODA  $\gg$  LEFTMOSTNESS. Hence the placement of the *-um-* prefix is prosodically determined, as the following tableau illustrates:

(33) Tagalog *gr-um-adwet*

Candidates	$\mathbf{P}$ (NO-CODA)	$\mathbf{M}$ (LEFTMOSTNESS)
um.grad.wet	* !	
gum.rad.wet	* !	g
<sup>gr</sup> gru.mad.wet		gr
grad.wu.met		gradw !

Some forms (e.g., *um-gradwet*) may violate NO-CODA in more than one location — for clarity, the tableau only records violations of NO-CODA involving the prefix *-um-*, since only those will differ crucially among candidates. The prefixed form *\*um-gradwet* and the post-C infix form *\*g-um-radwet* violate the dominant constraint NO-CODA, so they are eliminated from consideration. Those that pass NO-CODA, *gr-um-adwet* and *\*gradw-um-et*, are submitted to the  $\mathbf{M}$ -constraint LEFTMOSTNESS. The latter is non-optimal, though, since the infix is located in the second syllable rather than the first. Hence, the actual output form is *gr-umadwet*.

The account of Tagalog infixation in (32, 33) answers all the objections against a circumscriptional analysis. Because it relies on the prosodic well-formedness constraint NO-CODA, rather than prosodic circumscription, it does not have the liability of demanding that either *gr* or *adwet* be identifiable as a prosodic constituent. And because *\*g-um-radwet* violates NO-CODA just as *\*um-gradwet* does, this analysis explains why the infix must follow the entire onset in recent loans like *gradwet*. Finally, because the locus of *-um-* is determined directly by the phonology, via NO-CODA, the Optimality-Theoretic analysis provides a complete formal account of the observation that prenuclear *-um-* “makes sense phonotactically”.

In Tagalog, then, the schematic constraint hierarchy  $\mathbf{P} \gg \mathbf{M}$  characterizes a type of non-circumscriptional infixation. The crucial member of  $\mathbf{P}$  is NO-CODA and the crucial member of  $\mathbf{M}$  is LEFTMOSTNESS, though of course we may assume that other constraints belong to these blocks as well. In this way,  $\mathbf{P} \gg \mathbf{M}$  generalizes the theory of Prosodic Morphology beyond the

principles in (1), which apply only to circumscriptural and templatic morphology. The fundamental Optimality-Theoretic insight that permits this generalization is to see the interaction between prosody and morphology in Prosodic Morphology as one of constraint dominance, as in  $\mathbf{P} \gg \mathbf{M}$  or, in terms of the specific visibly active constraints whose relation is responsible for the effect,  $\text{NO-CODA} \gg \text{LEFTMOSTNESS}$ .

Of course, the  $\mathbf{P} \gg \mathbf{M}$  relation is not a matter of linguistic necessity; pure non-prosodic morphology observes the opposite relation,  $\mathbf{M} \gg \mathbf{P}$ . For instance, if  $\text{LEFTMOSTNESS}$  were to dominate  $\text{NO-CODA}$ ,  $\text{NO-CODA}$  would have no effect, as is the case with conventional prefixes, which are not subject to prosodic conditions on their location.

Thus far we have seen only one constraint from the  $\mathbf{P}$  block at work in infixation, but when a language has sufficient richness, more of  $\mathbf{P}$  can be manifest. Syllabic constraints like  $\text{ONSET}$  or  $\text{NO-CODA}$  can combine with circumscriptural ones like  $\text{ROOT-ALIGN}$  to yield a mixed system with a complex infix distribution. The Siouan language Dakota provides a case of this sort. (There are, however, various additional intricacies detailed by Moravcsik (1977:93-108), so our analytic proposals at this time must be taken *cum grano salis*.)

In Dakota, the agreement system consists of a set of perhaps twenty affixes that are prefixed to monosyllabic verb roots and some polysyllabic ones, but infixated into other polysyllabic verb roots. The roots taking infixes are apparently a lexically specified subclass, though historically they may have been morphologically composite. The locus of infixation is after the initial syllable, which is always open in Dakota (Shaw 1980):<sup>84</sup>

(34) Infixation of  $-wa-$  ‘I’ in Dakota

pa-wa-ŕta	‘I tie up’
ma-wa-ni	‘I walk’
ma-wa-nu	‘I steal’
ca-wa-pa	‘I stab’
‘i-ma-ktomi	‘I am Iktomi’
na-wa-pca	‘I swallow it’
na-wa-t’aka	‘I lock the door’
la-ma-k’ota	‘I am a Lakota’

The agreement morphemes of Lakota are fundamentally prefixes, so they are subject to  $\text{LEFTMOSTNESS}$ . But, for the infix-taking subclass of verb roots, these morphemes are barred from initial position by  $\text{ROOT-ALIGN}$ . The relation between these two constraints is set by  $\mathbf{P} \gg \mathbf{M}$ , so  $\text{ROOT-ALIGN}$  dominates  $\text{LEFTMOSTNESS}$ .

This interaction between  $\text{ROOT-ALIGN}$  and  $\text{LEFTMOSTNESS}$  forces the agreement morphemes out of absolute initial position, but the minimally-infixing candidate is incorrect:  $*\acute{c}\text{-wa-}.a.pa$ , for example, obeys  $\text{ROOT-ALIGN}$  and minimally violates  $\text{LEFTMOSTNESS}$ , yet it is non-optimal. Clearly another constraint is involved, and as the syllabification in  $*.\acute{c}\text{-wa-}.a.pa$  indicates, it is a member in good standing of the  $\mathbf{P}$ -group:  $\text{ONSET}$ , repeated here from (8):

---

<sup>84</sup>The examples in (34) are cited directly from Moravcsik (1977) and they preserve the dialectal and transcriptional idiosyncrasies of her sources.

(35) ONSET  
\*<sub>l</sub>[<sub>o</sub>V

Non-optimal \*.*č-wa-.a.pa.* crucially violates ONSET, as we shall see shortly. According to Boas and Deloria (1941:4), all empty onsets in surface forms are filled by *ʔ*. For the current argument, we assume that epenthesis of *ʔ* is a separate matter, outside the level at which the locus of infixation is determined. If this should turn out to be incorrect, then it is a straightforward matter to re-cast the argument using the P-constraint FILL rather than ONSET, so the crucially non-optimal candidate is instead FILL-violating \*.*č-wa-. $\square$ a.pa.*

The following tableau shows that, like ROOT-ALIGN, ONSET must dominate LEFTMOSTNESS:

## (36) /wa + čapa/

Candidates	P		M
	ONSET	ROOT-ALIGN	LEFTMOSTNESS
a. wa- $[\check{c}a.pa]_{PrWd}$		* !	
b. $[\check{c}-wa-.a.pa]_{PrWd}$	* !		č
c. $[\check{c}a.-wa-.pa]_{PrWd}$			ča

As the reader may verify, the system illustrated in (36) will yield the correct result for any root of the shape /CV~/ or /V~/ and for any affix of the shape /C~/.

What then of affixes /V~/C/? It turns out that there is a special set of conditions under which roots that are in the infixing class take *prefixed* agreement instead. The root itself must be V-initial. The affix involved is also V-initial, the second person dual, which is *ɥk* before vowels and *ɥ* before consonants.<sup>85</sup> This is the only /V~/C/ agreement morpheme in Dakota. Here are some examples, using the roots *manu* ‘steal’ and *ali* ‘climb’:<sup>86</sup>

## (37) Patterning of Root Type and Infix Type

	C~V affix /wa/ ‘1sg.’	V~C affix /ɥ(k)/ ‘1du’.
[C root    manu]	ma-wa-nɥ	ma-ɥ-nɥ
[V root    ali]	a-wa-li	<span style="border: 1px solid black; padding: 2px;">ɥk-ali</span>

The double-boxed example is the interesting one. In it, the unique V-initial agreement morpheme of Dakota is *prefixed* to a V-initial root. Naively, we would have expected \**a-ɥ-li* instead.

<sup>85</sup>This allomorphy is obviously ONSET-governed; see Mester (to appear) for relevant discussion.

<sup>86</sup>The examples in (37) have been cited from or constructed on the basis of the description in Boas and Deloria (1941:78f.).

Naive expectation is defeated by ONSET, which, as usual, has a role to play in determining the properties of vowel-initial morphemes. But it can play this role only if it dominates ROOT-ALIGN, as the following tableau demonstrates:

(38) ONSET  $\gg$  ROOT-ALIGN Ranking Argument

Candidates	ONSET	ROOT-ALIGN	LEFTMOSTNESS
a. $\text{☞}$ $\text{ɥ.k-a.li}$	*	*	
b. $\text{a.-ɥ-.li}$	** !		a

The candidates also differ on LEFTMOSTNESS, as shown, but that constraint is irrelevant here, since it is ranked below both of the constraints under consideration (v. (36) for the ranking argument). The actual output form  $\text{ɥ.k.a.li}$  contains a single ONSET violation (marked by the symbol  $\text{☞}$ ), while its nearest competitor contains two:  $\text{*ɥ.a-.ɥ.li}$ . Because ONSET dominates ROOT-ALIGN, the prefixed candidate is selected as the output.

Fixing this additional ranking does not affect the analysis of cases like (36), which involve no ONSET violations. Nor does it affect the analysis of cases that meet only one of the two conditions of a  $/V\sim C/$  affix with a  $/V\sim/$  root. Tableaux for  $\text{a-wa-li}$  and  $\text{ma-ɥ-nɥ}$  show this:<sup>87</sup>

## (39) C-Final Affix or V-Initial Root

a.  $/C\sim V/$  Affix +  $/V\sim/$  Root

Candidates	ONSET	ROOT-ALIGN	LEFTMOSTNESS
i. $\text{wa-.a.li}$	* !	*	
ii. $\text{☞}$ $\text{a.-wa-.li}$			a

b.  $/V\sim C/$  Affix +  $/C\sim/$  Root

Candidates	ONSET	ROOT-ALIGN	LEFTMOSTNESS
i. $\text{ɥ-.ma.nɥ}$	*	* !	
ii. $\text{☞}$ $\text{ma.-ɥ-.nɥ}$	*		ma

The candidate (39ai) violates both ONSET and ROOT-ALIGN, so ranking these two constraints with respect to one another merely assigns responsibility for the outcome without changing it.

<sup>87</sup>There are two further complications:

The unique  $/V\sim V/$  infix  $\text{-içi-}$  should fall in  $C\_\_\_$  locus, not  $CV\_\_\_$ , given the other constraints proposed. Perhaps an ALIGN-like constraint preserves the contiguity of base syllabification.

Monosyllabic roots are never in the infixing class, for obvious historical reasons. The analysis presented would predict suffixation with “infixing” monosyllabic roots, if any existed.

In (39b), the two candidates tie on ONSET, since each has a single onsetless syllable. As usual, the decision passes to the next constraint, ROOT-ALIGN, which selects the infix candidate over the prefixed one.

The complete hierarchy of constraints relevant to infixation in Dakota is ONSET  $\gg$  RT-ALIGN  $\gg$  LEFTMOSTNESS. Like the Axininca constraint hierarchy, the Dakota one follows the **P**  $\gg$  **M** schema in a fine-grained way. At the extrema are constraints that are purely within the **P** or **M** domains: ONSET and LEFTMOSTNESS. In between is a constraint that governs the interface between prosody and morphology, ROOT-ALIGN. Thus, within the **P**-block, we distinguish a sub-block **Φ** of phonological constraints from a sub-block **I** of interface constraints, with the relation **Φ**  $\gg$  **I**. From this ranking schema and three constraints, each of which represents a banal observation about Dakota grammar, we obtain a pattern of surprising subtlety, in which something that is nominally a prefix is infixated after the first syllable, unless phonotactic considerations demand that it be prefixed. It is the *interaction* of the constraints, rather than the statement of the constraints themselves, that supplies the intelligence behind this patterning.

To obtain a further, unexpected set of consequences from the **P**  $\gg$  **M** perspective, we turn to examine yet another infixation pattern. In a remarkably wide variety of languages, there is a type of reduplication that can be described as copying the first CV sequence of the word, skipping over an initial onsetless syllable. This pattern is found in the *Sanskrit* aorist and desiderative<sup>88</sup> (Kiparsky 1986; McCarthy and Prince 1986; Janda and Joseph 1986:89), the Austronesian languages *Pangasinán* of Luzon, Philippines (Benton 1971:99, 117) and *Timugon Murut* of Sabah, Malaysia (Prentice 1971), and the non-Austronesian languages of Papua New Guinea *Yareba* (Weimer and Weimer 1970, 1975:685), *Orokaiva* (Healey, Isoroembo, and Chittleborough 1969:35-36), *Flamingo Bay Asmat* (Voorhoeve 1965:51), and undoubtedly many others. The Timugon Murut reduplication in (40) is a typical example, showing that initial onsetless syllables are systematically skipped over:

(40) Timugon Murut Infixing Reduplication

bulud	<u>b</u> u–bulud	‘hill/ridge’
limo	<u>l</u> i–limo	‘five/about five’
ulampoy	u– <u>l</u> a–lampoy	no gloss
abalan	a– <u>b</u> a–balan	‘bathes/often bathes’
ompodon	om– <u>p</u> o–podon	‘flatter/always flatter’

Descriptively, a light syllable ( $\sigma_\mu$ ) template is infixated after an initial onsetless syllable, otherwise it is prefixed.

Though it might be possible to construct a circumscriptional analysis of facts like these (McCarthy and Prince 1991b), the result is quite unsatisfactory. For one thing, negative

<sup>88</sup>Some examples of Sanskrit aorist and desiderative reduplication:

(i) Aorists			
$\sqrt{\text{arc}}$	aar– <u>c</u> i–c–am	$\sqrt{\text{ubj}}$	āub– <u>j</u> i–j–am
$\sqrt{\text{arh}}$	ār– <u>j</u> i–h–am	$\sqrt{\text{rdh}}$	ār– <u>d</u> i–dh–am
$\sqrt{\text{iks}}$	āi– <u>c</u> i–kṣ–am		
(ii) Desideratives			
$\sqrt{\text{arh}}$	ar– <u>j</u> i–h–iṣa	$\sqrt{\text{und}}$	un– <u>d</u> i–d–iṣa
$\sqrt{\text{rdh}}$	ar– <u>d</u> i–dh–iṣa		

circumscription — extrametricality — of initial onsetless syllables requires identifying such syllables as a particular type of prosodic constituent, thus enriching the theory of prosodic categories. It seems likely that the other arguments in the literature for the extrametricality of such syllables are not correct: for example, there is considerable evidence against extrametricality of initial onsetless syllables in Axininca Campa (cf. §5 and the Appendix).<sup>89</sup> But these technical matters pale beside a far more serious problem: a circumscriptional analysis cannot explain why, in all known cases, it is always a *reduplicative* infix that skips over the initial onsetless syllable. Since the theory of Prosodic Circumscription completely divorces the morphological operation (in this case, prefixation of  $\sigma_\mu$ ) from the specification of the prosodic base (in this case, the residue of onsetless syllable extrametricality), by its very nature it cannot account for any dependencies between them. Indeed, this is precisely the same reason that Prosodic Circumscription cannot relate the VC shape of Tagalog *-um-* to its prenuclear locus.

But the broader conception of Prosodic Morphology, embodied in the **P** >> **M** ranking schema, provides a compelling non-circumscriptional account of infixation in Timugon Murut and similar cases. The key fact is that simple prefixation runs into problems with ONSET that infixation successfully avoids: reduplicating #VCV as #V-.VCV is manifestly less harmonic, syllable-wise, than reduplicating it as #V-CV-CV.<sup>90</sup> Edgemostness of the affix suffers, as always. With the **P** >> **M** schema, the Timugon Murut constraint system is not merely *analogous to* but actually *identical* to Tagalog's. The only difference is which of the **P**-constraints does the actual work — ONSET in Timugon Murut, NO-CODA in Tagalog — a fact that follows from the different lexical substance of the relevant morphemes, and merits no grammatical mention whatsoever.

The tableaux (41, 42) show how the correct result devolves from this ranking, assuming a set of candidates where the Reduplicant exactly matches the light syllable template.<sup>91</sup>

(41) Timugon Murut  $\sigma_\mu$  - Reduplication. C-initial Words.

Candidates	<b>P</b> (ONSET)	<b>M</b> (LEFTMOSTNESS)
☞ <u>bu</u> .bu.lud		
bu. <u>lu</u> .lud		bu !

Both candidates obey ONSET, so they are referred to LEFTMOSTNESS, which selects bu-*bulud*, whose prefix is perfectly prefixal.

<sup>89</sup>The arguments from the nonstressing of word-initial onsetless syllable in Arandic languages (Davis 1988b, Halle and Vergnaud 1987, Archangeli 1988) suggest the imposition of syllabic well-formedness conditions on the stress-peak, as suggested in Prince and Smolensky (1991a, 1993).

<sup>90</sup>As noted in the discussion of Dakota, if underlying onsetless syllables are parsed with epenthetic consonants, the **P**-constraint relevant here may be FILL rather than ONSET.

<sup>91</sup>Kiparsky (1986:74-75) proposes that the Murut (and Sanskrit) pattern of infixation is a consequence of extrametricality of onsetless initial syllables. He suggests in a footnote that infixation after the extrametrical syllable is a way to avoid violating the Peripherality Condition on extrametricality. This interesting idea has certain abstract similarities to our approach.

(42) Timugon Murut  $\sigma_\mu$ -Reduplication. V-initial Words.

Candidates	P (ONSET)	M (LEFTMOSTNESS)
<u>u</u> .u.lam.poy	* ! *	
u. <u>la</u> .lam.poy	*	u

But in (41) there is a crucial ONSET violation in \*l-*ulampoy* that is absent in *u-la-lampoy*. Since ONSET is ranked higher, it alone determines the outcome, though LEFTMOSTNESS would give the opposite result.

This argument relies on one tacit assumption, which we must make explicit to assure its validity. The assumption is that the Reduplicant, underlined as usual, is no more or less than a light syllable. This strict (=undominated) templatic requirement excludes candidates where the relation between the Reduplicant and syllabification is more indirect: from / $\sigma_\mu$  + *ulampoy*/ we could otherwise get \*u.l-*ulampoy*, with pure prefixation of the Reduplicant *ul-*, of which the *u* is syllabified in the templatic prefix and the *l* is accounted for by the first syllable of the root. Such patterns are not uncommon; Mangarayi (above, §7.2) is a close-by example, and McCarthy and Prince (1986) discuss similar configurations in Oygangand (Sommer 1981 and §7.4 below), Mokilese (Harrison and Albert 1976), and, with suffixing reduplication, Tzeltal (Berlin 1963, Kaufman 1971).

Below in §7.4 we will suggest a general approach to templatic requirements in terms of alignment constraints. The clear difference between Timugon Murut and the Mangarayi type lies in the alignment of morpheme-edge and syllable-edge, as can be seen in the following contrast:

(43) a. \*|.u.l|-u.lampoy                      b. .u-|.la|.-lampoy

In Timugon Murut, the edges of RED must exactly coincide with the edges of a light syllable, as in the form on the right. Timugon Murut, then, has an undominated templatic constraint RED= $\sigma$ . In contrast, the templatic constraint is dominated in Mangarayi and the other languages cited, leading to violation, as evidenced by trans-junctural syllabification in reduplicative contexts.

For Timugon Murut, the relevant constraints must be ranked as follows:

(44) ONSET, RED= $\sigma_\mu$  >> LEFTMOSTNESS

The effects of this hierarchy are seen in the following tableau:

(45) Timugon Murut  $\sigma_\mu$ -Reduplication, V-initial Words, Full Interaction

Candidates	P		M
	ONSET	RED= $\sigma_\mu$	LEFTMOSTNESS
u   .la   .lam.poy			u
.u .u.lam.poy	* !		
.u.l -u.lampoy		* !	

Since we have introduced alignment considerations into the discussion, it is worthwhile considering what effect they would have on the parallel process of *-um-* infixation in Tagalog. Though not obviously active in Tagalog infixation, which would not usually be described as templatic, they need do no harm to the analysis, so long as they are subordinate to the more purely phonological constraints, NO-CODA in particular. The affix *-um-* is *always* misaligned as *-u.m|*-, but this is forced by NO-CODA. Tagalog, then, makes it clear that the non-ranking of syllabic constraints and the relevant interface constraints in Timugon Murut must be resolved in favor of the syllabic constraints. As in Axinica Campa or Dakota, the **P**-block distinguishes a sub-block **Φ** of purely phonological constraints from a sub-block **I** of interface constraints, with the relation **Φ**  $\gg$  **I**. We note that there is some restricted freedom of movement among the constraints of the **I**-block, whereby certain **I** constraints can escape to dominate **Φ** constraints, ALIGN-L  $\gg$  ONSET being a typical example. Similarly, certain **I** constraints may be dominated by **M** constraints, as in the languages like Mangarayi, Oykangand, Mokilese, and Tzeltal which syllabify across the Reduplicant-Base juncture, where we must have EDGEMOSTNESS or MAX (or both) dominating the relevant templatic constraint. It is clear, however, that the scheme **Φ**  $\gg$  **I** is commonly obeyed, preserving syllabic well-formedness in the face of morphological distinctness, forcing VC+V to syllabify as mis-aligned V.C+V, for example.

Back to Timugon Murut. Unlike accounts based on circumscription, this analysis does not require that the onsetless syllable be recognized as a type of prosodic constituent. Indeed, the Optimality account is free of parochial mention of any constituent or configuration. All previous accounts call on some kind of rule that examines and parses the *input*; these rules must mention details of shape of the affix and of the shape of the base: infix morphemes VC past initial C-cluster; infix morphemes  $\sigma_\mu$  past a V-initial syllable. The Optimality-Theoretic approach, by contrast, treats the grammar of, e.g., Tagalog and Timugon Murut as exactly identical, and the principles involved are only the recognized, entirely general constraints whose force is felt throughout phonology and morphology.

Even more remarkably, this mode of analysis explains why only *reduplicative* prefixes, and never *segmental* prefixes, are subject to infixation after initial onsetless syllables. The core of the explanation is apparent from *\*.u-.ulampoy* in (41b). In such purely prefixing candidates, the Reduplicant *copies* an ONSET violation; but a segmentally-fixed morpheme cannot have this kind of pathological interaction with the Base. To make the claim perfectly clear, we will divide it up into its constituent parts and demonstrate it carefully. First, we define the relevant distribution:

(46) **Dfn.** Post-Initial Onsetless (PostIOS) Distribution.

If a morpheme  $\alpha$  is a *prefix* before *C*-initial stems and an *infix* falling immediately after an initial onsetless syllable, we say that  $\alpha$  has the PostIOS distribution.

This distribution is exactly that predicted by circumscription of an initial onsetless syllable. The first result concerns nonreduplicative morphemes.

(47) **Theorem I. Infixation of Segmental Specified Prefixes.**

Under the Optimality Theory schema  $\mathbf{P} \gg \mathbf{M}$ , no morpheme of fixed segmental content may have the PostIOS distribution.

**Proof.** To establish this, we do not need to examine the fate of every possible Base CV pattern; we need only exhibit one pattern which  $\mathbf{P} \gg \mathbf{M}$  cannot force into the PostIOS scheme of infixation. This Base serves as a witness that the PostIOS distribution can't be uniformly enforced in Optimality Theory.

Such a Base pattern is  $\#V.C\sim$ . It turns out that there is no possible increase in harmony that can be achieved by positioning a prefix  $\alpha$  as  $\#V\alpha CV$ . The fundamental problem is that this placement exposes the initial V, incurring an ONSET violation for which there is no compensation. To see this in detail, we can simply review the possibilities, where what's crucial is the segmentalism at the edges of  $\alpha$ . Here are the cases:

- If  $\alpha = cxv$ , infixation trades one ONSET violation for another  
 $\#cxv\text{-}\star V.C\dots$  vs.  $\#\star V\text{-}cxv\text{-}C\dots$
- If  $\alpha = vxv$ , infixation trades 2 ONSET violations for 2 more.  
 $\#\star vxv\text{-}\star V.C\dots$  vs.  $\#\star V\text{-}\star vxv\text{-}C\dots$
- If  $\alpha = cxc$ , infixation adds an ONSET violation & a NOCODA violation  
 $\#cxc\text{-}V.C\dots$  vs.  $\#\star V\text{-}cxc\text{-}C\dots$
- If  $\alpha = vxc$ , infixation adds an ONSET violation and a NOCODA violation.  
 $\#\star vxc\text{-}V.C\dots$  vs.  $\#\star V\text{-}\star vxc\text{-}C\dots$

In sum, if  $\alpha = XV$ , infixation as  $\#V\alpha C\sim$  maintains the level of ONSET violation; if  $\alpha = XC$ , it adds an ONSET violation and a NOCODA violation.<sup>92</sup> In no case is the infixed form syllabically superior; the decision must go to LEFTMOSTNESS, and a classical prefix results. Observe that the proof deals with a completely ordinary Base and not some special arrangement of C's and V's: if a language allows onsetless initial syllables at all, it must have words beginning  $\#V.C\sim$ .  $\square$

The other side of the argument consists of showing that a reduplicative morpheme with the PostIOS distribution does in fact exist. This might seem obvious, since we have just reviewed several actual cases where Optimality-Theoretic grammars yield reduplicative infixation. But the actual is often more cooperative than the ideal.

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<sup>92</sup>To get the NOCODA violation, we need to assume that there is no syllabification  $\sim x.c\text{-}CV$  across the infix-Base juncture. Though not absolutely mandated by the theory, the assumption is pretty secure, given the usual ALIGN-mandated preference for sharp syllabic junctures over mere maximization of a filled onset. As is clear from the proof, NOCODA violation is not essential to the argument anyway, so long as ONSET is at play.

Under the schema  $\mathbf{P} \gg \mathbf{M}$ , reduplication of an onsetless syllable will fatally decrement the harmony of a candidate, so long as any superior alternative exists. This applies not only to Bases like Timugon Murut *.u.lampoy* and *.om.podon*, which begin with a single onsetless syllable, but even more forcefully to any Base, like hypothetical *.u.o.e.a.pata*, which begins with a string of such syllables. In such cases, the prediction is that a reduplicative infix like  $\sigma_\mu$  will lodge before the first *C* it can find: so, *.u.o.e.a.-pa-pata*. No language we have seen offers such Bases, and the prediction has never been tested.<sup>93</sup> To get a general theorem, though, we modify our statement of the desired distribution:

(48) **Dfn.** Pre-First Onset (PreFO) Distribution.

If a morpheme  $\alpha$  is positioned immediately before the first C-initial syllable of the Base (and as a strict prefix before Bases consisting entirely of onsetless syllables) we say that  $\alpha$  has the PreFO distribution.

The parenthesized clause is added to clarify the prediction of the theory; no language with the relevant morphology has words consisting entirely of onsetless syllables, as far as we know. Note that no fixed-content morpheme can have the PreFO distribution; the argument just given for PostIOS applies equally well to PreFO:

(49) **Corollary (Theorem I).**

Under the Optimality Theory schema  $\mathbf{P} \gg \mathbf{M}$ , no morpheme of fixed segmental content may have the PreFO distribution.

**Proof.** By the argument for Theorem I, no fixed-content prefix  $\alpha$  can be placed as  $\#V\alpha CV\sim$ .  $\square$

The result we want, of course, is that there are indeed patterns of reduplicative infixation that follow the PreFO distribution.

(50) **Theorem II. Reduplicative Infixation (Prefixing).**

Under the Optimality Theory schema  $\mathbf{P} \gg \mathbf{M}$ , there can be reduplicative morphemes with the PreFO distribution.

**Proof.** To show this, it suffices to establish that some one reduplicative template can be PreFO-distributed. For concreteness, let us take  $\sigma_\mu$ . We assume that the templatic constraint  $\text{RED}=\sigma_\mu$  is undominated. We also assume that **PARSE** and **FILL** belong to the  $\mathbf{P}$  block.

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<sup>93</sup>Bella Coola core syllable reduplication provides a potential parallel. Bagemihl (1991) reports that the reduplicative prefix lodges before the first CV of the word, where V means sonorant rather than strictly vocalic. Thus it skips over initial sequences of obstruents CCC..., as in */qpsta/*  $\rightarrow$  *qps-ta-ta-* ‘taste $\rightarrow$ iterative(actual)’, much in the way reduplicative affixation is posited to skip over sequences VVV... . Phonetically, the obstruents get syllabified as syllable heads, according to many observers; Bagemihl demonstrates that such syllables do not count for reduplication, and proposes that they are absent from the phonology. Optimality Theory allows us to reopen the question, and consider that this might be a case of prosodically compelled infixation, where the forcing constraint is ‘obstruents are not nuclei’, which is violated in the language at large, but asserts itself when possible.

To show that a morpheme is truly PreFO-distributed, we must review its placement in all possible circumstances. Fortunately, there are only four Base patterns to consider:

1.  $(.V)^*.CX$              $(X \neq \emptyset)$
2.  $(.V)^*.VC.CX$          $(X \neq \emptyset)$
3.  $(.V)^*.VC.$
4.  $(.V)^*$

The syllabifications shown are those that the Base would receive in isolation.

The first observation to make is that in no case will RED be planted *inside* an initial sequence of syllables  $.V$ . This adds a single ONSET violation. But simple prefixation also adds a single ONSET violation, and succeeds better (i.e. completely) on LEFTMOSTNESS. Therefore, since simple prefixation is superior, internal placement can *never* be optimal.<sup>94</sup> From this, it follows immediately that case 4 will yield prefixation, in accord with PreFO. Let us now deal with the remaining three cases:

**Case 1.** RED+ $(.V)^*.CX$ .             $(X \neq \emptyset)$

By what has just been said, the contest is between simple prefixation and pre-first-C placement, as in  $(.V)^*.\sigma_{\mu}.CX$ . With the pre-C placement, the affix lies in the leftmost position that incurs no ONSET violation, so the form is optimal.

**Case 2.** RED+ $(.V)^*.VC.CX$ .  $(X \neq \emptyset)$

Here there is a choice between locating the affix before the first C and locating it before the first onsetted syllable. Infixation before the first onset incurs only a LEFTMOSTNESS violation. The pre-first-C placement, as in  $(.V)^*.V-\sigma_{\mu}.CX.$ , is not viable despite its superior leftmostness. Under CONTIGUITY, there can be no nucleus for the Reduplicant copied from the Base, so a nuclear FILL violation is inevitable in the Reduplicant. With FILL in the **P** block, this is sufficiently fatal.<sup>95</sup>

**Case 3.** RED+ $(.V)^*.VC.$

Here there are really three choices: prefixation, pre-C placement, and post-C placement or pseudo-suffixation. Prefixation introduces a new ONSET violation. Post-C placement results in a null Base, yielding FILL violations in the exponent of the morpheme RED, because it has nothing to parasitize for its melody; and even worse, violation of CONTIGUITY, which demands that material in the Reduplicant be indexed to corresponding material in Base. Pre-C placement has the same effects as in case 2: it must result in at least one FILL violation (nucleus of the

<sup>94</sup>This argument holds even if simple prefixation is itself suboptimal. In the terms of Prince & Smolensky (1993:§9), internal placement into a V-string is *harmonically bounded* by prefixation: there is always a *better* alternative candidate, so that internal placement can never be the *best*. We do not need to know what the best candidate actually is to make this argument, just what the better one is.

<sup>95</sup>The pre-first-C placement is beset with other problems as well, each individually fatal. What is to become of that first C? If it is syllabified into the affix as a coda, the reduplicative template RED= $\sigma_{\mu}$  is violated; even if the affix is merely  $\sigma$ , a template violation results, since the exponent of RED does not end up occupying an *entire* syllable. If the C is left unsyllabified, a PARSE violation results. If the C is supported by epenthetic structure, yielding  $(.V)^*.V-\sigma_{\mu}.CA-.CX.$ , a second FILL violation results. By contrast, locating the affix before the first onsetted syllable yields a Reduplicant that satisfies the templatic constraint, leaves nothing unparsed, introduces no empty structure, and itself has an onset. Its only defect is violation of LEFTMOSTNESS, but the extent of violation is the minimal one that makes it possible to satisfy the phonological and interface constraints.

Reduplicant), plus PARSE or RED= $\sigma_\mu$  violation. Since absolute prefixal placement violates only ONSET, there will be a number of domination relations, for example FILL  $\gg$  ONSET, which will suffice to secure prefixation. Thus, as claimed, it is possible to force prefixation in this circumstance.  $\square$

The essential correctness of this perspective is confirmed by the existence of a near mirror-image of the Timugon Murut pattern, in which the reduplicant follows a word-final vowel (V+RED#) but is infixed before a word-final consonant (RED+C#). Cases of this sort can be found in Kamaiurá (Everett and Seki 1985, who however offer a different analysis) and Chamorro (Topping 1973:183, 215-6):

(51) Kamaiurá Infixing Reduplication, RED=Ft

o-huka	ohuka- <u>huka</u>	‘he laughed/kept laughing’
o-mo-tumuŋ	omotumu- <u>tumu</u> -ŋ	‘he shook it/repeatedly’
je-umirik	jeumiri- <u>miri</u> -k	‘I tie up/repeatedly’
o-je-ʔapah <sup>w</sup> at	ojeʔapah <sup>w</sup> a- <u>pah</u> <sup>w</sup> a-t	‘he rolls himself up/repeatedly’
o-etun	oetu- <u>etu</u> -n	‘he smells/keeps on smelling’
a-pot	apo- <u>apo</u> -t	‘I jump/repeatedly’
o-ekij	oeki- <u>eki</u> -j	‘he pulls/repeatedly’

(52) Chamorro Infixing Reduplication, RED= $\sigma$

dánkolo	dánkolo- <u>lo</u>	‘big/really big’
buníta	buníta- <u>ta</u>	‘pretty/very pretty’
nálaŋ	nála- <u>la</u> -ŋ	‘hungry/very hungry’
métgot	métgo- <u>go</u> -t	‘strong/very strong’

Infixation of the Kamaiurá/Chamorro Reduplicants also involves the general **P**  $\gg$  **M** schema, but with the responsible **P** constraint being **P** = NO-CODA (9a) and the **M** constraint being RIGHTMOSTNESS, which controls suffixation. Here again, there are no known cases of a segmental infix with this distribution. It is possible to show that prosodic constraints can never force a segmentally-specified morpheme to sit before a final C. To establish this, let us proceed as before, carefully stating the distribution, then examining the relevant cases.

(53) **Dfn.** Pre-Final C (PreFC) Distribution.

If a morpheme  $\alpha$  is positioned immediately before the final C of the Base, and as a strict suffix after V-final Bases, we say that  $\alpha$  has the PreFC distribution.

This description is exactly that predicted by circumscription of a final consonant. We have the following result.

(54) **Theorem III. Infixation of Segmentally Specified Suffixes.**

No segmentally-specified morpheme can have the PreFC distribution under the schema **P**  $\gg$  **M**.

**Proof.** We consider only words ending in a single consonant. As before it is sufficient to show

one pattern that cannot be compelled to admit the PreFO distribution. Consider  $\sim\text{CVC}\#$ . The question is, how can  $\sim\text{CV}\alpha\text{C}\#$  possibly be superior to  $\sim\text{CVC}\alpha\#$ ?

- Suppose  $\alpha = \text{vx}$ . Infixation introduces a new NOCODA violation, and very likely an ONSET violation as well.

$\sim\text{CV.Cvx}$ . vs.  $\sim\text{CV}\underline{\text{vx}}\underline{\text{C}}$ .

- Suppose  $\alpha = \text{cx}$ . Infixation maintains the level of NOCODA violation.

$\sim\text{CV}\underline{\text{C}}.\text{cx}$ . vs.  $\sim\text{CV}.\text{cx}\underline{\text{C}}$ .

Since infixation is either worse or the same on **P**, rightmostness from **M** compels suffixation.

□

We need to establish now that a reduplicative morpheme *can* have the PreFC distribution, or something much like it, so that patterns like those of Kamaiurá and Chamorro can be generated. As above, the picture is enriched by the possibility of strings of onsetless syllables. As noted in the proof of Theorem II, reduplication under **P**  $\gg$  **M** will not position  $\sigma$  amid V-strings, leading to gratuitous copying of ONSET violations. The distribution we actually seek, then, is not ‘before the final C’ but ‘after the last CV’. We want to place  $\alpha$  as  $\sim\text{CV}\alpha\text{V}^*\text{C}$ .

(55) **Dfn.** Post-Last CV (PostLCV) Distribution.

If a morpheme  $\alpha$  is placed right after the last CV sequence in a word (and as a suffix in words with no CV) then we say that  $\alpha$  has the PostLCV distribution.

The proof just given for Theorem III applies as well to the PostLCV distribution:

(56) **Corollary** (Theorem III).

No morpheme of fixed segmental composition can have the PostLCV distribution.

**Proof.** By Theorem III, no such morpheme can be inserted before the final CV in words of the form  $\sim\text{CVC}\#$ . □

Now we state the result for reduplicative morphemes:

(57) **Theorem IV. Infixation of Reduplicative Suffixes.**

Under **P**  $\gg$  **M**, there are reduplicative morphemes with the PostLCV distribution.

**Proof.** Suffixation requires a little more work than prefixation because of asymmetries in syllable structure. We proceed by developing a constraint hierarchy that will yield the result for a Chamorro-like system where the template is given by  $\text{RED}=\sigma$ . Notice first that the template itself must be violated to a degree in C-final forms:

(58) Template Violation

a. .met.go-. <u>g</u> o-t.	R= go, $\sigma$ = .go-t.
b. .ná.la-. <u>l</u> a-ŋ.	R= la, $\sigma$ = .la-ŋ.

The template is  $\sigma$  but the Reduplicant does not fill it entirely; it is jostled in  $\sigma$  by a stem consonant. (By contrast, with infixation after V there is little chance that the initial V will join the reduplicated syllable.) With the template violable in this way, another candidate presents itself:

## (59) Template Violation

- a. \*.met.go.t-ot. R= ot,  $\sigma$  = .t-ot.  
 b. \*.ná.la.ŋ-aŋ. R= aŋ,  $\sigma$  = .ŋ-aŋ.

Here a root consonant intrudes into the template from the other side. This form of reduplication is attested in Mayan languages like Tzeltal (Berlin 1963, Kaufman 1971, McCarthy & Prince 1986) and in various Salishan languages. It has the not inconsiderable virtue of being fully suffixal. Since both infixation (58) and suffixation (59) violate the  $\sigma$  template, apparently equally, the question arises as to how they are to be distinguished. We suggest that the difference lies in the extent to which the Reduplicant mirrors the Base. In the infixing version (*metgogot*), there is exact correspondence between syllabic roles of Reduplicant and Base; in the suffixing form (*\*metgotot*), there is an inevitable mismatch: the final C of the Reduplicant is moraic but its image in the Base is a weightless onset. Let us assume that the maximality of the copying relationship between Base and Reduplicant is evaluated over all structure that the Reduplicant carries; this is clearly a function of MAX or of a MAX-related constraint. For concreteness let us name the relevant condition STROLE for ‘Structural Role’. The constraint STROLE must dominate RIGHTMOSTNESS so that the more faithful copy, though infixed, is chosen over the strict suffix. Putting the central P-constraints ONSET and NOCODA in place, we will have the following rankings:<sup>96</sup>

## (60) Chamorro-type Suffixal Infixational Constraint System

ONSET, NOCODA  $\gg$  STROLE  $\gg$  RIGHTMOST  $\gg$  RED= $\sigma$

To see how this works on the crucial C-final example, examine the following tableau (we omit ONSET as it does no work here):

## (61) /nálaŋ/ + RED

Candidates	NOCODA	STROLE	RIGHTMOST	RED= $\sigma$
a.  .ná.la-. <u>la</u> -ŋ.	*		ŋ	*
c. .ná-. <u>na</u> -.laŋ.	*		laŋ !	
b. .ná.la.ŋ- <u>aŋ</u> .	*	* !		*
d. .ná.laŋ- <u>laŋ</u> .	** !			

<sup>96</sup> NOCODA and STROLE cannot be ranked with respect to each other; either order gives the same results. We follow the P  $\gg$  M schema in placing NOCODA up with ONSET, which (as we will see) must be crucially ranked above STROLE.

Simple whole-syllable suffixation (d) copies a NOCODA violation, which disqualifies it immediately. Suffixation with partial copy (c) is as syllabically successful as any of the remaining candidates, but it entails a syllable-role mismatch, fatal because other candidates are well-matched. Candidate (b) copies an open syllable, but the same overall success on NOCODA is achieved in (a), which achieves superior rightmostness. Thus, placing the  $\sigma$ -affix right after the last CV — the PostLCV distribution — is required for C-final stems.

In the case of stems ending in CV, like /bunita/, it is clear that pure suffixation is optimal, since every constraint of prosody, morphology, and interface is completely satisfied.

Suppose now that the word is shaped  $\sim CV.V^+\#$ , so that the last CV is separated by a string of onsetless syllables from the edge. Under our assumption that the **P** block is complete and contains ONSET, it is clear that the affix cannot be placed amid the V-string. Placement after the last CV assures syllabic well-formedness at the expense of subordinate Rightmostness. Once again the PostLCV distribution is guaranteed.

The final remaining situation is one in which there is no CV substring at all in the entire word. The pattern must be  $\#V^+(C)\#$ . If the word is all vowels, suffixation results in ONSET violation, but infixation offers no advantages in this respect.<sup>97</sup> If the word ends in a consonant, suffixation is optimal because the suffixed form  $\#V^+.C\text{-vc}\#$  has but one NOCODA violation, and any infixed form, e.g.  $\#V^+.vC\#$  will match it in that respect and add an ONSET violation. The suffixed form has, however, the disadvantage of violating STROLE and  $RED=\sigma$ , both of which are satisfied by the infixing form. This shows that to get the result we must add the requirement  $ONSET \gg STROLE$ , which is of course expected under the **P**  $\gg$  **M** format. With this, the demonstration is complete.  $\square$

The PostLCV distribution can, then, be attained under the schema **P**  $\gg$  **M**, where **P** comprehends both ONSET and NOCODA, and **M** consists of a mini-hierarchy that ranks the reduplicative constraint STROLE, the affixal placement constraint RIGHTMOSTNESS, and the templatic constraint  $RED=\sigma$ .

The **P**  $\gg$  **M** schema leads to a considerably sharpened understanding of the nature and typology of affix placement. Previous theory offers no insight at all into the interactions between prosodic well-formedness and affixation, and consequently provided no account of the relation between affix shape and affix placement, and, further, had no means to predict differences in infixability between reduplicative and segmentally-specified affixes. Earlier functionalist commentary, on the other hand, spotted important factors but had no means to advance beyond the *post hoc* to fashion them into real predictions. The current theory is a first step which opens the area to investigation and, as such, can claim some basic successes but hardly completeness. The rawest prediction of the reduplicative theory is that an affix like  $\sigma$  should, under prosodic compulsion, move inward to the edgemoat position where copying does not multiply syllabic flaws that would otherwise be incurred; this allows, in principle, a variety of aggressive placements beyond those discussed here. The rawest prediction of the segmental theory is that the segmentalism of an affix can lead it to be placed in an edgemoat position where it alleviates some syllabic problem; again, this leads to the possibility of some aggressive placements (for example, vxv infixed to break up a CC cluster; cxc infixed to break up a VV cluster) which are not likely to be found. The theory makes correct and unprecedented predictions in the central

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<sup>97</sup>Note that we are assuming no VV coalescence involving the reduplicative morpheme. Strictly speaking, this ought to be added to the hypothesis of the theorem.

cases recorded in Theorems I-IV, indicating that further exploration into this newly opened area should lead to significant progress.

Generalizing still further, the **P** >> **M** schema reveals an important abstract connection between the infixing reduplication of languages like Timugon Murut and the total reduplication of Axininca Campa. In both languages, imposition of the **P**-constraint ONSET on the Reduplicant leads to special behavior, in which a broadly-based **M**-constraint on the Reduplicant is violated. In the case of Timugon Murut, the **M**-constraint violated is LEFTMOSTNESS, and the resulting special behavior is infixation after an initial onsetless syllable. In the case of Axininca Campa, the **M**-constraint violated is MAX, and the resulting special behavior is incomplete reduplication, as in *osampi-sampi* or *oiriŋkA-riŋkA*. So Timugon Murut and Axininca Campa differ only in what the crucially dominated **M**-constraint is, leading to different resolutions of the potential ONSET violation in the Reduplicant.

Classic Prosodic Circumscription theory is able to capture abstract resemblances of this sort only in part, and at the cost of empirical inadequacy. Chamorro would have extrametricality of final C (clusters); Tagalog would have extrametricality of initial C (clusters). The chief difficulty is that circumscription allows a choice between different types of extrametricality where no choice is known to exist; a subsidiary difficulty inheres in the problem of defining exactly what *unit* is supposed to be extrametrical, since the theory works on constituents. Timugon Murut and Axininca Campa would share extrametricality of initial onsetless syllables, which affects the affixation operation in Timugon Murut and the copying operation in Axininca Campa. But it has been shown (above and §6) that extrametricality is fundamentally flawed in either case. Furthermore, extrametricality can only account for cases where the initial onsetless syllable is morphologically inert; yet the consequences of imposing ONSET on the Reduplicant go beyond morphological inertia. And of course, extrametricality must mention specific units in specific positions, so it cannot hope to unite all such cases under one banner.

The generalization inherent in the **P** >> **M** schema is even greater than bringing together two cases where onsetless initial syllables are at issue. Under Optimality Theory, the *grammars* of Timugon Murut, Tagalog, Chamorro, and Axininca Campa are essentially identical, despite the fact that the concrete problems of each are quite different, involving fixed-content morphemes, reduplicative morphemes, suffixes, prefixes, and so on. The differences turn out to lie in the lexical items that are assembled into complex structures. These fundamentally lexical differences lead to very diverse-looking consequences under the same constraint hierarchy. This configuration is virtually inevitable under Optimality Theory: if the constraints out of which grammars are constructed are universal, they must be very abstract; if they are abstract, their consequences must be rich and, at times, unexpected.

There are yet further effects of the **P** >> **M** schema beyond shape and placement of affixes. We noted above that aorist and desiderative reduplication in Sanskrit follow the Timugon Murut infixing pattern, with the PIOS distribution, in which ONSET crucially dominates LEFTMOSTNESS (Whitney 1924:§862, §1029b). Another kind of reduplication, the  $\sigma_{\mu\mu}$ - prefix forming the Intensive of verbs (e.g., *carḱarḱ-*) is simply *impossible* with V-initial roots (with a single exception; Whitney 1924:§1001; Steriade 1988a:112-3). The approach of Steriade (1988a) aims to attribute the blocking of intensive reduplication with V-initial roots to ONSET, an important

insight which is basic to understanding the phenomenon.<sup>98</sup>

The behavior of the Sanskrit Intensive recalls the phenomenon of prosodic delimitation (v. §7.2 above). In a prosodically defined class — the V-initial roots — a morphological construction is blocked. The analysis, then, follows the model shown in (17, 18): a **P**-constraint, here ONSET, crucially dominates the **M**-constraint M-PARSE. Intensive reduplications of V-initial roots receive the null parse; they simply do not exist.

In the case of the Sanskrit intensive, the failure is complete, as it is in the English comparative or the Kinande noun. In the case of the Sanskrit perfect, also reduplicative with prefix  $\sigma_{\mu}$ , a small number of V-initial roots form a perfect in which the Reduplicant is replaced by the prefix  $\bar{a}n-$  (Whitney 1924:§788).<sup>99</sup>

### (62) Sanskrit $\bar{a}n-$ Perfects

$\sqrt{a\bar{n}j}$	$\bar{a}n-a\bar{n}j-a$
$\sqrt{a\bar{c}}$	$\bar{a}n-a\bar{c}-ma$
$\sqrt{rdh}$	$\bar{a}n-rdh-\acute{u}s$
$\sqrt{arc}$	$\bar{a}n-arc-a$

In the case of the Sanskrit perfect, then, a second construction can be called on to substitute, as in the Dyirbal ergative. The basic explanation — ONSET  $\gg$  M-PARSE — is the same as in the intensive.

With these Sanskrit data, we have now seen three fundamentally different responses to imposition of ONSET on the Reduplicant:

- infixation, violating LEFTMOSTNESS, as in Timugon Murut, the Sanskrit aorist and desiderative, and so on.
- partial reduplication, violating MAX, as in Axininca Campa.
- blocking, violating M-PARSE, as in the Sanskrit intensive and the perfect of some roots.

Extrametricality can perhaps be tweaked to provide descriptions for both infixation and partial

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<sup>98</sup>There are, however, significant difficulties with the implementation Steriade explores. It is not clear how *blocking* is possible at all, since Full-Copy theory otherwise relies on *repair* as the mechanism for satisfying templatic requirements. (See §6 for discussion. The blocking/repair problem is common to all theories that combine constraints and rules.) And, like approaches based on extrametricality, it can establish no relation between blocking (of intensive reduplication) and infixation (in the aorist and desiderative).

Steriade (1988a:82) also suggests that imposition of ONSET can force *expansion* of a template, by supplying it with a segmentally empty onset position. Evidently the intention here is that *only* templates will be so affected, an impossibility in our terms, since ONSET  $\gg$  FILL would be expected to have other consequences in the language. The cases offered in evidence, Kamaiurá and Chukchee, seem to be amenable to reanalysis. On Kamaiurá, see below (51); on Chukchee and the related Koryak, see fn. 56.

<sup>99</sup>Roots /VC/ have reduplicated perfects in which the Reduplicant and Base are fused into a single syllable, so no new ONSET violation is introduced (Whitney 1924:§783):

(i) Perfect Reduplication of /VC/ Roots

$\sqrt{ad}$	$\bar{a}d$
$\sqrt{is}$	$\bar{i}s$

In diphthongal roots (*guna* of those in (i)) a glide fills the onset of the Base syllable:

(ii) Perfect Reduplication of /aVC/ Roots

$\sqrt{ais}$	$iyes$
$\sqrt{auc}$	$uvoc$

Roots shaped /VVC/ and /VCC/ do not reduplicate in the perfect.

reduplication, with loss of generalization, but by its very nature it can say nothing about the blocking pattern. Familiar (though often tacit) theories of phonological well-formedness constraints routinely deal with blocking behavior, but of course they say nothing about infixation and partial reduplication. These failures of standard approaches stem from a fundamental inability to deal with the *diversity* of effects of imposing ONSET on the Reduplicant. In contrast, the far more abstract  $\mathbf{P} \gg \mathbf{M}$  schema reveals the fundamental property uniting all of these cases: a  $\mathbf{P}$ -constraint, here ONSET, crucially dominates one of the  $\mathbf{M}$ -constraints LEFTMOSTNESS, MAX, or M-PARSE. All reflect central generalizations that any morphological analysis must state; it is their interaction with ONSET, under Optimality Theory and  $\mathbf{P} \gg \mathbf{M}$ , that derives a complex pattern of interlinguistic variation.

#### 7.4 Templates and Template Satisfaction

The discussion to this point has shown that, within Optimality Theory, the role of prosody in morphology can be subsumed under a general relation of constraint ranking, represented by the schema  $\mathbf{P} \gg \mathbf{M}$ . This is part of a new statement of the fundamental principles of Prosodic Morphology, repeated here from §7.1:

##### (63) New Prosodic Morphology

###### a. Prosodic Morphology Hypothesis

Templates are constraints on the prosody/morphology interface, asserting the coincidence of morphological and prosodic constituents.

###### b. Template Satisfaction Condition

Templatic constraints may be undominated, in which case they are satisfied fully, are they may be dominated, in which case they are violated minimally, in accordance with general principles of Optimality Theory.

###### c. Ranking Schema

$\mathbf{P} \gg \mathbf{M}$

In this final section we turn to the role of templates in this newly restructured theory of Prosodic Morphology. Taking the constraint DISYLL as a starting point, we will show that the two remaining characteristics of the original theory, the Prosodic Morphology Hypothesis and the Template Satisfaction Condition, devolve from much more general aspects of the prosody/morphology relation. Templates, it will be seen, are special cases of the alignment of prosodic and morphological categories, familiar from constraints like ALIGN (§4.2) and SFX-TO-PRWD (§4.3). It will also emerge that the Template Satisfaction Condition reflects only one particular ranking of a templatic constraint relative to other constraints and that other rankings are possible, as the general theory predicts.

Recall (from §5.3) the discussion of the constraint DISYLL, which requires that the Reduplicant be minimally disyllabic. Classical Prosodic Morphology, through the Prosodic Morphology Hypothesis (1a), requires that a template be a single prosodic category. But DISYLL cannot be identified with a standard template. Disyllabicity is not an absolute requirement of shape-invariance, like familiar templates, but only a lower bound, since trisyllabic reduplicants are impeccable. Thus it cannot be identified with the category *Foot*, which imposes both upper

and lower bounds. Furthermore, a disyllabic quantity-**insensitive** foot would be required, yet this is incompatible with the thorough-going quantity-sensitivity of prosody in Axininca Campa.

These characteristics of DISYLL establish that the classical notion of template and template-satisfaction needs to be generalized. (See also the discussion of Mangarayi, above §7.2.) The generalization is to be found in the family of constraints on the morphology/prosody interface, such as ALIGN, which are themselves ultimately connected with the Chen/Selkirk model of the syntax/prosody interface. An ALIGN-theoretic version of DISYLL, repeated here from §5.3, is this:

(64) DISYLL

The left and right edges of the Reduplicant must coincide, respectively, with the left and right edges of *different* syllables.

Higher-ranking constraints ensure that all candidate Reduplicants surviving as far as DISYLL have left and right edges that coincide with syllable boundaries. Then DISYLL further requires that they be the boundaries of *different* syllables, thereby ensuring that the Reduplicant is minimally disyllabic.

Classical templates can be described in similar terms, as constraints on the prosody/morphology interface, though classical templatic constraints will in general be simpler than DISYLL. Indeed, under the Prosodic Morphology Hypothesis, a classical template is really nothing more than an assertion about how some morphological category, such as the ‘plural’ Reduplicant in Ilokano or the Stem of an Arabic verb, is to be aligned with some prosodic category, such as a heavy syllable or a trochaic foot. Classical templates are, by their very nature, specifications of how morphology and prosody are aligned with one another.

A classical template, then, is a particularly simple kind of constraint on the prosody/morphology interface, one in which identity alone is enough:

(65) Constraint Schema for Classical Templates

$MCAT=PCAT$

where **Mcat**  $\equiv$  Morphological Category  $\equiv$  Prefix, Suffix, RED, Root, Stem, LexWd, etc.

and **Pcat**  $\equiv$  Prosodic Category  $\equiv$  Mora, Syllable (type), Foot (type), PrWd (type), etc.

Templatic constraints typically identify the type of prosodic category referred to, such as light versus heavy syllable, species of foot (McCarthy and Prince 1991a, b), and so on. Thus, the heavy-syllable template for the Ilokano plural in (3) will be expressed by the constraint  $RED=\sigma_{\mu\mu}$ . Alternatively, finer typology can be achieved by conjoining prosodic specifications. For example, the Ilokano plural template can be expressed by the constraint  $RED=\sigma=FT$ , since a heavy syllable is the only prosodic unit that is both a syllable and a foot.

The constraint schema (65) is also applicable to word-minimality effects. As we noted in the discussion of FTBIN (37) in §4.3, observed word-minimality restrictions follow from the grammatical requirement that a certain morphological unit correspond to a Prosodic Word. This requirement is embodied in the following constraint (McCarthy and Prince 1991a):

## (66) Imposition of Word Minimality

$$\text{MCAT}=\text{PRWD}$$

where **Mcat** = Root, Stem, LexWd

The various possible specifications of **Mcat** determine the level or stratum at which word-minimality requirements are imposed, either initially, on roots, or later, in conjunction with affixation. By requiring that a particular morphological category correspond to a Prosodic Word, the constraint  $\text{MCAT}=\text{PRWD}$  ensures that that morphological category will inherit the minimality property of Prosodic Words demanded by the Prosodic Hierarchy in conjunction with FTBIN, as explicated in §4.3. The various **Mcat**'s listed in (66) are simply those that are root-headed, in conformity with the (normally undominated) constraint  $\text{PRWD}\supset\text{ROOT}$  ((59) in §5.4).

Classical templates and observed word minimality requirements are the standard arguments for the Prosodic Morphology Hypothesis (McCarthy and Prince 1986). We have seen, though, that classical templates and minimality requirements can be expressed by constraints on the prosody/morphology interface of a particularly simple type, requiring complete identity between a morphological and a prosodic category. If templates truly *are* identity constraints on the prosody/morphology interface, then the fact that they are expressed in terms of prosodic units goes without saying — they could not be otherwise. Hence, the Prosodic Morphology Hypothesis is correct as an observation about the structure of templates, but superfluous as a claim about linguistic theory. Once the true nature of templatic constraints is understood, the Prosodic Morphology Hypothesis follows as a necessary consequence of the fundamental character of a broad range of prosody/morphology constraints, of which templates are just a part.

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From the perspective of classical Prosodic Morphology, the other peculiarity of DISYLL is that it is *violable*.<sup>100</sup> The Template Satisfaction Condition requires, in effect, that templatic requirements be transparent: a templatic requirement must be met by every member of the morphological class based on that template. But Axininca Campa has monosyllabic, DISYLL-violating Reduplicants of two types: those based on unprefixated /CVV/ roots *naa-naa-~* and those based on unprefixated /C/ roots *pAA-pAA-~*.<sup>101</sup> Thus, DISYLL in Axininca Campa stands in direct contradiction to the Template Satisfaction Condition.

Similarly, the templatic constraint of Mangarayi (§7.2)  $\text{RED}=\sigma$  is among the violable constraints of that language, crucially dominated by LEFTMOSTNESS and ROOT-ALIGN, forcing Reduplicants like *img* that bear only a passing resemblance to a syllable. Indeed, this crucially violable template is an essential property of the analysis of all systems in which there is

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<sup>100</sup>On other grounds, Perlmutter (1992b) has proposed that templates may contain formally optional elements, a very different kind of departure from the Template Satisfaction Condition.

<sup>101</sup>The Reduplicant *is* minimally bimoraic, without exception. This is not a separate constraint, but rather emerges as a theorem of the system. The Base must always be bimoraic, because of SFX-TO-PRWD and FTBIN. Any augmentation of a sub-bimoraic Base must appear at its right edge, because of ALIGN-L. The Reduplicant must faithfully copy the material at the right edge of the Base, because of ANCHORING. Thus, a set of undominated (or at least FILL-dominating, in the case of SFX-TO-PRWD) constraints ensures that at least a bimoraic Base will be copied in the Reduplicant.

syllabification across the Reduplicant-Base juncture, like Mangarayi, Oykangand, Mokilese, or suffixing reduplication in Tzeltal.

To confirm this result, let us delve a little more deeply into Oykangand (Sommer 1981), examining the facts reported in (67).<sup>102</sup>

(67) Reduplication in Oykangand

/eder/	<u>ed</u> -eder	‘rain’
/algal/	<u>alg</u> -algal	‘straight’
/igu-/	<u>ig</u> -igun	‘go’

Oykangand words may not begin with consonants. Sommer has taken this to mean that Oykangand **syllables** must — *contra naturam* — be similarly restricted, at least underlyingly; he cites reduplication as presumptive evidence for the claim, proposing that it copies a ‘syllable’, i.e. VC\*. Since such an operation is in all likelihood impossible, rather than merely unusual (as Sommer himself suggests), the reduplication evidence cannot support the syllabic claim.

The present theory interprets the matter very differently, specifying the template as RED=σ, but crucially violable, under the compulsion of the universally-expected (and phonetically observable) syllabification of the language. In particular, universal ONSET must dominate the template, and together with dominant LEFTMOSTNESS it will force violation of RED=σ whenever the root is V-initial. Since, as noted, all Oykangand roots are V-initial,<sup>103</sup> it follows that the normal Oykangand Reduplicant is descriptively VC\* – not because VC\* is a syllable, but because it is the minimal violation of RED=σ that is consistent with dominant ONSET.

Another species of violation of a templatic constraint is observed in Manam (Lichtenberk 1983, McCarthy and Prince 1986:38-40). Manam has a bimoraic Reduplicant, so the templatic constraint is RED=FT. It dominates MAX, as shown by the disposition of Bases greater than a single foot in (68c). But FILL must dominate RED=FT, because the templatic requirement is not supported by epenthesis in the case of monomoraic Bases (68a):

(68) Manam Reduplication

a. ra- <u>ra</u>	‘talk to’
pi- <u>pi</u>	‘be forceful’
b. laʔo- <u>laʔo</u>	‘go’
c. salaga- <u>laga</u>	‘long’
moita- <u>ita</u>	‘knife’
malabom- <u>bon</u>	‘flying fox’

<sup>102</sup>Sommer (1981) additionally cites a pattern of internal reduplication for some polysyllabic stems:

/iyalme-/	iy- <u>alm</u> -almey	‘play’
/anaŋumi-/	anaŋ- <u>um</u> -umin	‘peek’

Without a more extensive account of Oykangand phonology and morphology, it’s not entirely clear what to make of these examples. Sommer also cites the pair /oyelm/ ‘back again’, *oyel-oyelm* ‘straight back again’, which he notes is limited to this one word.

<sup>103</sup>Accounting for *this* observation is not an easy thing; no known syllabic or prosodic constraint will exclude C-initial roots.

There are other interpretations of (68a) (Lichtenberk 1983, McCarthy and Prince 1986), but the natural one in the present context is that *ra-ra* violates RED=FT because of dominant FILL:

(69) FILL  $\gg$  RED=FT, in Manam

Candidates	FILL	RED=FT
a. $\text{ra-ra}$		*
b. $\text{raTA-raTA}$	*   ***	

The FILL violations in the Reduplicant are immediately fatal to all augmenting forms, including *raTA*, *TArA*, *raA* (= *ra $\mu$* , as in (71a)), and so on.<sup>104</sup> The template, then, is only an upper bound, symmetric to the lower-bounding behavior of DISYLL.

From the perspective of Optimality Theory, the violability of DISYLL in Axininca Campa, of RED= $\sigma$  in Mangarayi and Oykangand, or RED=FT in Manam is not peculiar at all; in the context of Optimality Theory, this is entirely routine behavior for a dominated constraint. Rather, it is the general transparency of the classical templatic constraints — their apparent *inviolability* — that is unexpected.

Templatic transparency, when it is observed, has a straightforward explanation in terms of constraint domination. A transparent template is undominated; in particular, it must dominate constraints that could otherwise force violation, particularly FILL and MAX. Consider, for example, a typical templatic constraint of the always-obeyed, utterly transparent, classical variety, RED= $\sigma_{\mu\mu}$  in Ilokano. Transparency of a templatic constraint is unremarkable in cases like those in (3a), when MAX alone ensures that the template is fully satisfied. (That is, there is no constraint conflict.) The interesting cases are those like (3b), repeated for convenience in (70), where the Base supplies material that is insufficient or unsuitable for satisfying the template:

(70) Reduplication of Ilokano /CV $\text{?}$ ~/

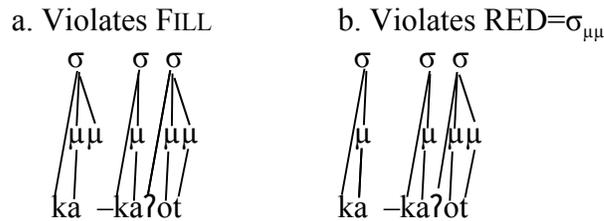
ka $\text{?}$ ót	‘s.t. grabbed’	<u>ka</u> :ka $\text{?}$ ót	‘id. (pl.)’
ró $\text{?}$ ót	‘leaves, litter’	<u>ró</u> :ró $\text{?}$ ót	‘id. (pl.)’

More exact copies like \**ka $\text{?}$ -ka $\text{?}$ ót* would better conform to MAX, but they are prohibited by the dominant CODA-COND, which bars  $\text{?}$ -final syllables in Ilokano. Other possibilities such as \**kat-ka $\text{?}$ ót* or \**?ót-ka $\text{?}$ ót* are excluded by undominated CONTIGUITY and ANCHORING (§5.2).

Dismissing the various non-viable candidates from further consideration, we can locate the entire Ilokano transparency effect in the comparison between *ka*:ka $\text{?}$ ót and \**ka*-ka $\text{?}$ ót, which are represented as follows:

<sup>104</sup>We assume undominated CONTIGUITY and ANCHORING (§5.2). If these constraints are disregarded, then \**ra-raTA* is more harmonic, but still incurs fatal FILL violations.

## (71) Viable Candidates for Reduplication of Ilokano /CVʔ~/



Form (71b) obviously violates the templatic constraint, because the exponent of RED, the Reduplicant, is a light syllable, not a heavy one. Form (71a) violates FILL, because the Reduplicant is parsed with an empty mora, but it satisfies the templatic constraint. The empty mora, we assume, is realized as lengthening of the preceding vowel in the interpretation of the output form.<sup>105</sup>

FILL and the Ilokano templatic constraint RED=σ<sub>μμ</sub> conflict in examples like (71). They are ranked as follows:

(72) RED=σ<sub>μμ</sub> ≫ FILL, from /RED-kaʔót/

Candidates	RED=σ <sub>μμ</sub>	FILL
a.  ka:-kaʔót (= (71a))		*
b. ka-kaʔót (= (71b))	* !	

The templatic constraint RED=σ<sub>μμ</sub> must also dominate MAX, in conformity with the general **P** ≫ **M** ranking schema, as we argued above in §7.2. Thus, the full constraint hierarchy is as follows:

## (73) Constraint Hierarchy — Ilokano Reduplication

RED=σ<sub>μμ</sub> ≫ FILL, MAX

This situation is typical of a classical template. Its complete transparency, or seeming inviolability, comes from dominating two of the principal constraints that could force violation: FILL, which would otherwise compel violation when the input is insufficient; and MAX, which would otherwise compel violation when the base is superabundant (thereby swamping the template in an exact copy of the Base).

<sup>105</sup>See §2.3, where this assumption is laid out. Alternatively, one might assume that (71a) includes the association line added between the melodeme *a* and the second mora of the Reduplicant. In that case, FILL should be replaced in the subsequent discussion by the faithfulness constraint that demands conservation of association lines.

Hayes and Abad (1989:361) observe that another Ilokano dialect realizes the empty μ by gemination of the following consonant: *ʔag-dad-dáʔit* ‘is sewing’. This sort of variation is to be expected, if the realization of the empty μ is a relatively superficial matter of interpreting the output of the phonology. Potentially more problematic is their observation that, even in the dialect with vowel lengthening, “a restricted set of stems reduplicates with gemination: *tat-táʔo* ‘persons’, ...”. Obviously, the relatively simple hypothesis about derived vowel length embodied in (71a) needs further exploration.

We have seen, then, that template transparency, as required by the Template Satisfaction Condition, is just one of the ways in which a templatic constraint may function in a system within Optimality Theory. Other options are logically possible and actually attested. Thus, the generalization expressed by the Template Satisfaction Condition is at best a tendency for templatic constraints to be FILL-dominating; it is not an invariant law of language.



## 8. Conclusion

Here we briefly recall the main lines of the argument. In dealing with the complex of empirical issues in Axininca Campa, there emerged some patterns of explanation that seem to us to be of particular interest:

- the limitation of onsetless syllables to PrWd-initial position, a consequence of undominated ALIGN-L barring initial epenthesis.
- required epenthesis at /V+V/ juncture, the effect of ALIGN, which demands the coincidence of stem-edge and syllable-edge.
- augmentation, especially the limitation of augmentation to roots before C-initial suffixes. This follows from ONSET, CODA-COND  $\gg$  SFX-TO-PRWD, ensuring that V-initial suffixes cannot select a PrWd-Base.
- epenthesis and augmentation in the Reduplicant mimicking that of the Base, a consequence of undominated ANCHORING and CONTIGUITY.
- non-copying of onsetless syllables in long roots. This follows from low-ranking MAX, in particular ONSET  $\gg$  MAX.
- non-copying of prefixes, except with short roots. This too follows from low-ranking MAX, in particular  $R \leq \text{ROOT} \gg \text{MAX}$ . The prefix nevertheless copies with short roots, because DISYLL  $\gg R \leq \text{ROOT}$ .
- PrWd-compounding reduplication with short V-initial roots. This follows from the violability of  $R = \text{SFX}$ , which is ranked below DISYLL.

It is also worth noting that the analysis rests on a complete grammar of FILL violation and reduplication in the language.

In pursuing the details of Axininca Campa morphology and phonology, we have found specific evidence for all of the central tenets of Optimality Theory:

- Constraint ranking and violability. Applications of these notions may be found on every page; without them, the enterprise would have failed at the outset. For example, all four constraints on the Reduplicant in Axininca Campa are violated in at least one surface form. The interface constraints ALIGN and SFX-TO-PRWD, though indispensable to the analysis, are violated systematically when they conflict with syllabic well-formedness. We have also called attention to various cases where the optimal form violates particularly many constraints (e.g., (25) in §5), though crucially low-ranking ones. This illustrates a particular consequence of the constraint hierarchy that Prince and Smolensky (1993) call “the strictness of strict domination”.
- Parametrization via ranking. The claim of Optimality Theory that interlinguistic differences stem from constraint ranking found strong support in the ALIGN-L/ONSET interaction. Rather than parametrizing ONSET by limiting it to PrWd-initial position, we found that the apparent restriction on ONSET followed by a constraint-ranking relation, specifically ALIGN-L  $\gg$  ONSET.

- Inclusiveness of the candidate set. This is most striking in the case of candidate Reduplicants — *any string at all* is a legitimate candidate Reduplicant, meriting scrutiny by the constraint hierarchy. An important empirical result of inclusiveness is the alternation between suffixed and compounded Reduplicants, seen in words of the *asi//asi* type.
- Parallelism of constraint satisfaction. A specific argument for parallelism comes from augmented reduplications like *naTA–naTA*, in which the Reduplicant both **triggers** augmentation and **copies** it.

Moreover, the cross-language results for Prosodic Morphology theory detailed in §7 depend in various essential ways on constraint ranking, constraint violability, and language parametrization via ranking.

A substantive and perhaps unexpected finding is the centrality of the theory of *alignment*. Violable constraints demanding the alignment of prosodic and morphological constituents improve upon the results obtained previously through mechanisms like the phonological cycle and extrametricality. This opens up areas for future research, promising a novel perspective on issues that might have seemed to have little left to offer.

The basic theme of this work is the development of a theory that elaborates Prosodic Morphology within Optimality Theory. We have argued for four main theses, by example throughout the text and explicitly and at length in §7:

- P**  $\gg$  **M**. In all cases of prosodic morphological phenomena, prosodic constraints dominate morphological ones.
- Constraint typology. Templatic and circumscriptive constraints are members of a broad family of constraints on the *alignment* of morphological and prosodic categories.
- Template Satisfaction and Circumscription. The satisfaction of templatic and circumscriptive requirements is by evaluation of an inclusive set of candidates, not by rules or repairs. The candidates are assessed in parallel.
- Violability. Templatic and circumscriptive constraints, like all other constraints, are violable if dominated.

These claims refine rather than revolutionize the received understanding of Prosodic Morphology, but they are different enough to lead to a set of empirical results that previous theory could not hope to express. They emerge as a natural development, made possible through the fundamental notions of Optimality Theory.

## Appendix: Stress and Velar Glide Loss

The main analytic focus of this study has been on the reduplicative phenomena and related phonology of Axininca Campa. Two other aspects of the phonology of the language — stress and velar glide loss — shed considerable additional light on the prosody–morphology interface and on the relationship of the lexical levels. It is important, therefore, to examine these remaining parts of the phonology with an eye to the way they integrate into the overall scheme of the grammar.

### A.1. Word-level Phonology

We will begin by establishing that stress and velar glide loss cannot be accounted for within the Suffix-level constraint system of §4 and §5. We will do this by showing informally that the constraints responsible for stress and velar glide loss cannot be satisfied in parallel with other Suffix-level constraints. Instead, stress and velar glide loss are the consequences of a separate but closely related constraint system, the Word-level phonology, that applies to the (interpreted) output of Suffix level.

The constraint SFX-TO-PRWD will, in general, require recursion of the category PrWd in the output of Suffix level:

#### (1) Recursion of PrWd

[[[ naTA]–naTA]–wai–T–ak–i]

In this example, PrWd-hood is imposed on the Base *naTA* by the suffix RED, as evidenced by the augmentation (§4.3, §5.2). The continuative suffix *–wai* also imposes PrWd-hood on the Base *naTAnaTA*, though vacuously, since FTBIN is satisfied without further ado. The remaining suffixes, *–ak* and *–i*, cannot impose SFX-TO-PRWD without violating ONSET or CODA (v. §4.3, especially (58)).

Recursion of PrWd is an essential feature of the analysis of the augmentation phenomenon in the Suffix-level phonology. But it is incompatible with several elementary properties of the Word-level prosody, as shown by the following evidence:

#### (i) PrWd-final syllables are unstressed, but syllables that end an internal PrWd are stressable.<sup>106</sup>

[[[ kow <sup>ˈ</sup> A]–kow <sup>ˈ</sup> A]–wáiTaki]	‘has continued to search more and more’
[máto]	‘moth’

#### (ii) PrWd-final syllables are short, but syllables that end an internal PrWd can be long:

[[[ n- <u>apii</u> ]–n- <u>apii</u> ]–waiTaki]	‘I will continue to repeat more and more’
[ ápi ] [ apiiwaiTaki ]	‘has continued to repeat more and more’

#### (iii) Surface feet can straddle Suffix-level internal PrWd boundaries, although the Prosodic Hierarchy asserts, *inter alia*, that PrWd properly brackets Ft:

[[[ (no-mà) ( <u>na</u> )– <u>pi</u> ] (t <sup>h</sup> aČáa)]–ri]	‘I will hide to see him’
[[[ (h-awi) ( <u>hA</u> )– <u>pi</u> ] (t <sup>h</sup> aTá) (n-akí)]–ri]	‘he passed by him, departing’

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<sup>106</sup>The first example is phonemicized from Payne, Payne, and Santos (1982:231); those in (iii) from *ibid.*, 232-3.

It is apparent that only the outermost instance of PrWd is relevant to the observed Ft-parse and to the special prominential treatment of PrWd-final syllables.

Since stress is sensitive only to the outermost PrWd, while the Suffix-level constraint SFX-TO-PRWD must have access to the fully recursive PrWd, it follows that surface stress cannot be determined in the Suffix-level constraint system. Rather, stress is fixed in the Word-level constraint system, whose input is the interpreted output of the Suffix level. That is to say, the system of constraints relevant to surface stress patterns is visibly active at a level subsequent to the Suffix-level phonology, in which the recursion of PrWd has been leveled out in favor of a flat structure.

A closely related issue arises with instances of Ft posited in the Suffix-level phonology. Within Prosodic Morphology theory, the explanation for the bimoraic target of augmentation (§4.3) follows from the Prosodic Hierarchy, specifically the requirement that PrWd contain a Ft meeting FTBIN. Thus, any augmented form must be represented with foot structure in the Suffix level phonology:

(2) [ (na<sup>T</sup>A) ] –piro—~

If the Ft-parse is exhaustive, or nearly so, at Suffix level, then the result may be completely at odds with the Ft-parse actually observed in the output of Word level. The following example compares the assumed output of Suffix level (3a) with the observed output of Word level (3b):

(3) Suffix-level Ft Parse (cf. (iii) above)

- a. [[[ (nomà) na ] –(pit<sup>h</sup>à)(Čáa) ] –ri]  
 b. [ (nomà)(napi)(t<sup>h</sup>aČáa)ri]

In (3a), the underlined syllable *na* cannot be included in the Ft-parse without violating SFX-TO-PRWD. The Ft-parse that yields the observed stress placement (3b) plainly disregards the feet posited in the Suffix level phonology. Thus, Suffix-level feet do not persist into the Word-level phonology.

This leveling of the recursive PrWd and loss of foot structure, which occur as part of the interpretation of the output of Suffix level, are a version of the ‘deforestation’ of Liberman and Prince (1977) and subsequent work in metrical theory, and are strongly reminiscent of a familiar principle of the theory of Lexical Phonology — Bracket Erasure (Pesetsky 1979, Kiparsky 1982, Mohanan 1982, Inkelas 1989). In its various incarnations, Bracket Erasure accounts for the common observation that aspects of the internal structure of one level of the phonology are not available to rules or principles applying on later levels. We will define Bracket Erasure very narrowly, so that it affects only PrWd-internal instances of Ft and PrWd. Thus, the formulation in (4) is sufficient:

(4) Bracket Erasure

$$[X [Y]_{\alpha} Z]_{\text{PrWd}} \rightarrow [X Y Z]_{\text{PrWd}}, \quad \alpha = \{\text{Ft}, \text{PrWd}\}$$

More radically, we might suppose that Bracket Erasure affects all PrWd-internal prosody that is not lexically distinctive — essentially, all except moraic structure.

Bracket Erasure applies at every stage of the derivation, which amounts to applying it at the interface between levels, since the Optimality-Theoretic model recognizes no other derivational stages. Thus, in the interface between Suffix-level and Word-level, the complex structure of feet and internal words is reduced, and so simple representations like the following are submitted to the Word-level constraint system:

(5) [kowakowawaitaki]<sub>PrWd</sub>

As noted in §3, the idea that there is a special character to the interface between levels is a prominent feature of work by Goldsmith (1990, 1991), and is echoed here by the proposal about Bracket Erasure.

As stated in (4), Bracket Erasure conserves the compound structure of words of the *asi//asi* type (§5.4). These forms emerge from the Suffix-level constraint system as Prosodic Word compounds, though obviously the right branch of the compound may have PrWd recursion (due to SFX-TO-PRWD) like any other suffixed form:

(6) [asi] [[asi]–waitaki]

Bracket Erasure preserves the compound structure, though it simplifies the recursive structure.<sup>107</sup>

(7) [asi] [asiwaitaki]

As we will see below (v. also §5.5), this Prosodic Word compound structure is required in the Word level phonology, as evidenced by phenomena of final stresslessness and final vowel shortness. The compounding facts show that we can't simply use wholesale deforestation to remove *all* prosodic structure from the output of the Suffix level — we must instead limit it to PrWd-internal prosody.

It is important to note that Bracket Erasure as stated in (4) does not obliterate **any** information about the morphological structure of forms. This accounts for the fact that the prefix/root distinction remains accessible at Suffix level, as required by  $R \leq \text{ROOT}$  (see §5.3), and that the prefix/root/suffix distinction remains accessible at Word level, as required by RT-SFX-SEGREGATION (see below, (55)). In this respect our conclusions concur with those of Inkelas (1989:56-7) and others who have argued that only the prosodic and not the morphological analysis is subject to Bracket Erasure.

Bracket Erasure is one kind of reduction in structural complexity that occurs at the interface between levels. Another is the spell-out of unfilled syllabic positions and the erasure of unparsed segmental material. As we argued in §3, this interpretation of the mismatches between prosodic and segmental structure is required to make sense of the different ranking of PARSE and FILL in the Prefix-level and Suffix-level phonologies. It is also required in the analysis of the velar glide  $\upsilon$ , as we will now show. Again, this relatively informal explanation somewhat anticipates the fuller development below.

When the velar glide  $\upsilon$  is adjoined on both sides by light syllables, it is normally absent, with the result that the abutting vowels are fused into a single heavy syllable:

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<sup>107</sup>This assumes that the whole *asi//asi* compound is not itself a PrWd. We know of no evidence that it is.

## (8) Velar Glide Loss in Light-Light Context

/ic <sup>h</sup> inau <sub>ɥ</sub> -iro/	ic <sup>h</sup> ina <u>i</u> ro	‘he raised it’
/hau <sub>ɥ</sub> -akiro/	ha <u>a</u> kiro	‘he has taken it’
/ita <sub>ɥ</sub> -akiro/	ita <u>a</u> kiro	‘he has burned it’
/hira <sub>ɥ</sub> -antawori/	hira <u>a</u> ntawori	‘(reason) that he mourned it’

When one or both of the abutting syllables is heavy, though, the velar glide is preserved, since its loss would lead to an illicit trimoraic or longer sequence:

## (9) Velar Glide Preservation in Light-Heavy, Heavy-Light, or Heavy-Heavy Context

/tau <sub>ɥ</sub> -aanc <sup>h</sup> i/	tau <sub>ɥ</sub> aanc <sup>h</sup> i	‘to burn’
/hoyaa <sub>ɥ</sub> -akiro/	hoyaa <sub>ɥ</sub> akiro	‘he has inserted it’
/oyaa <sub>ɥ</sub> -aanc <sup>h</sup> i/	oyaa <sub>ɥ</sub> aanc <sup>h</sup> i	‘to insert’
/ita <sub>ɥ</sub> -aiyironi/	ita <sub>ɥ</sub> aiyironi	‘they burned it’

Standardly, the conditions on velar glide preservation are attributed to syllabic well-formedness (Payne 1981:71, Yip 1983, Black 1991a, Spring 1991).

In the examples cited in (8) and (9), the velar glide is followed by a vowel-initial suffix. The behavior of the velar glide is the same when it is followed by an underlying consonant-initial suffix, including RED, which is always C-initial if suffixed (§5.2):

## (10) Velar Glide Before Consonant-Initial Suffix

a. /au<sub>ɥ</sub>-C/—Velar Glide Loss

/onta <sub>ɥ</sub> -waitiroota/	onta <sub>ɥ</sub> waitiroota	‘she might continually burn it’
/na <sub>ɥ</sub> -RED-waitaki/	na <sub>ɥ</sub> waitaki	‘I will continue to take more and more’
/a <sub>ɥ</sub> -RED-waitaki/	a <sub>ɥ</sub> waitaki	‘has continued to take more and more’

b. /aa<sub>ɥ</sub>-C/—Velar Glide Preservation

/oyaa <sub>ɥ</sub> -waitiroota/	oyaa <sub>ɥ</sub> waitiroota	‘she might continually insert it’
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This behavior only makes sense if <sub>ɥ</sub>-epenthesis in the underlying /au<sub>ɥ</sub>-C/ cluster *precedes* velar glide loss (Payne 1981, Yip 1983:249, Black 1991a:211, Spring 1991). Then the derived representation /onta<sub>ɥ</sub>waitiroota/ will pattern like (8), while the derived representation /oyaa<sub>ɥ</sub>waitiroota/ will pattern like (9). If velar glide loss were to occur in parallel with epenthesis, rather than serially, it would render epenthesis (that is, a FILL violation) completely superfluous, regardless of constraint-ranking. Velar glide loss and syllabic well-formedness could be achieved in the V<sub>ɥ</sub>C environment by velar glide loss alone, rather than by velar glide loss plus epenthesis.

This ordering argument shows that velar glide loss cannot be part of the phonology of Suffix level, since loss of the velar glide follows on Suffix-level epenthesis. Indeed, according to the principles of level organization laid out in §3, the input to Word level includes all of the results of Suffix-level epenthesis fully spelled-out, so epenthetic <sub>ɥ</sub> and underlying *a* are identical. This conforms to the observations: the phonological disposition of *aua* sequences is the same whether the *a* following the <sub>ɥ</sub> is underlying or epenthetic. Therefore, the constraints

responsible for loss or retention of  $\omega$  must, like the constraints pertaining to stress, be incorporated into the Word-level grammar.

In summary, the mapping between the output of Suffix level and the input to Word level necessarily calls on two kinds of reductions in structural complexity. The PrWd-internal instances of Ft and PrWd are leveled out to a single, superordinate PrWd by Bracket Erasure (4). And the unfilled syllable positions of the Suffix-level output are cashed in for full vowels and consonants, identical to underlying *a* and *t*. (As we observed in §3, this phonological realization of FILL and PARSE violations is independently required in the Prefix-level/Suffix-level interface as well.) Henceforth, we will adopt the convention of using virgules to indicate the input to the Word level in this sense, since it is underlying with respect to the Word-level constraint system. We will reserve italics for candidate outputs of the Word level.

## A.2. Stress and Related Phenomena

Our goal in this section is to provide a comprehensive account of the *prosodic* aspects of the Axininca Campa stress system. We will not attempt to deal with the various complications in the *prominential* aspects of Axininca stress (for which see Payne, Payne, and Santos (1982:185-195), Spring (1990a:58-68), and Hayes (1991:246-253)), since they are extraneous to our main concerns.

In Axininca Campa, the basic stress pattern is iambic (as usual, of the “left-to-right” variety). In accordance with universal stress theory (McCarthy and Prince 1986, Hayes 1987, Hayes 1991), iambic feet are of the form Light-Heavy, Light-Light, or Heavy. (All stress data come from Payne, Payne, and Santos 1982.)<sup>108</sup>

### (11) Basic Stress Data

(hinó)ki	‘arriba (por el río)’
(ič <sup>h</sup> i)(kaki)na	‘él me ha cortado’
(iráa)(wanà)ti	‘su caoba’
(apà)(nirói)ni	‘solo’
(añàa)(wái)(tiri)ka	‘cuando hablamos con él’

The most significant departure from iambicity comes from the fact that final syllables, except those containing diphthongs, are always unstressed (12a). As a consequence, disyllabic words actually have trochaic stress (12b).

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<sup>108</sup> Apparently closed (i.e., CVN) syllables are analyzed as heavy in the stress system, though there is no evidence for heaviness of closed syllables elsewhere in the language. Indeed, there is positive evidence for the lightness of closed syllables in the genitive suffix allomorphy phenomenon (v. section 6), since a root like /c<sup>h</sup>iŋki/ ‘eel’ patterns as bimoraic in selecting the *-ni* allomorph of the genitive. We do not address this problem, nor do we consider here an odd sort of extra-weak syllable, whose onset is *s* or *c<sup>h</sup>*.

## (12) Final Syllable Stresslessness

a. kimítaka ~ kimítàka	‘quizá’
hotítana ~ hotítàna	‘él me metió’
irániri	‘su cuñado’
č <sup>h</sup> óokiro	‘hormiga de árbol’
c <sup>h</sup> irìnitakòiyanaákani	‘la noche les sobrevino’
b. círi	‘brea de árbol’
máto	‘polilla’
c <sup>h</sup> ími	‘colpa’

In long words with trailing even-parity sequences of light syllables, like (12a), a secondary stress on the penult is variably realized under complex conditions (Payne, Payne, and Santos 1982:193). We will assume that it is authentically present in the phonology, though it is not always expressed in impressionistic prominence.

Prince and Smolensky (1992, 1993:§4) argue that final stresslessness effects do not reflect extrametricality (as in Hayes 1991:253), but rather the appearance of a truly trochaic foot in final position. Thus, a word like *máto* is a single bimoraic foot, not an otherwise impossible monomoraic foot plus a loose syllable, \**má<to>*. Similarly, all even-parity forms will end on a trochee: (*kimí*)(*tàka*), and so on for the others in (12a). This requires that a trochaic foot be optimal under some conditions even within a fundamentally iambic system. Thus, even the constraint of foot form — iambic here — is in principle (and in fact) violable.

This basic pattern of iambic stress with final stresslessness can be obtained, as in Prince and Smolensky (1992, 1993), from the interaction of FTBIN with three other constraints, pertaining to the foot type, the exhaustivity of foot parsing, and the special status of final syllables:

## (13) FT-FORM

Feet are iambic.

## (14) PARSE-SYLL

Syllables are parsed by feet.

## (15) NONFINALITY

The PrWd-final syllable is unstressed.

FT-FORM simply establishes as a formal (and violable) constraint the prominential and quantitative properties of iambic feet in universal stress theory. PARSE-SYLL is also a familiar requirement from stress theory (e.g., Liberman and Prince 1977:266, 294; Prince 1980:535; Halle and Vergnaud 1987; Hayes 1987). We assume that syllables are optimally parsed by Ft, in accordance with PARSE-SYLL, but failing that they are parsed by PrWd (cf. Itô and Mester 1992). Finally, NONFINALITY is the constraint proposed by Prince and Smolensky that does work in the stress domain similar to that previously associated with a notion of extrametricality (e.g.,

in Hayes 1980, Prince 1983, Harris 1983, Halle and Vergnaud 1987).<sup>109</sup> In the language of the constraint, ‘stressed’ means ‘the head of a foot’; unstressed, ‘not the head of a foot’.

These three constraints plus FTBIN are almost fully rankable, though establishing all of the details of the ranking requires some scrutiny of the situation. Short, even-parity words like *círi* have trochaic stress; thus, iambic FT-FORM is subordinated to final stresslessness:

(16) NONFINALITY  $\gg$  FT-FORM, from *círi*

Candidates	NONFINALITY	FT-FORM
(círi)	* !	
☞ (círi)		*

With the opposite ranking, NONFINALITY would have no effect. Since FT-FORM applies to every foot, and NONFINALITY only to a proper subspecies of them, this is the typical relation of a specific and a general constraint in Optimality Theory, following from Pāṇini’s Theorem (v. §5.2 and §7.2 above and Prince and Smolensky 1993:§7).

Long words like *kimitàka*, with an even-parity light syllable sequence, show that PARSE-SYLL also dominates FT-FORM. In the failed candidate, final stresslessness is achieved by non-exhaustive Ft-parsing:

(17) PARSE-SYLL  $\gg$  FT-FORM, from *kimitàka*

Candidates	PARSE-SYLL	FT-FORM
☞ (kimí)(tàka)		*
ki(mitá)ka	* ! *	

Both candidates in (17) satisfy NONFINALITY, since they do not have final stress. But the failed candidate has multiple violations of PARSE-SYLL, while the optimal candidate is fully parsed at the expense of positing a final trochee.

So far we have only looked at even-parity words, which show that NONFINALITY and PARSE-SYLL dominate FT-FORM, subordinating the requirements of iambicity to final stresslessness and completeness of the foot-parse. The treatment of odd-parity words like *hinóki* shows that PARSE-SYLL is itself dominated by FTBIN:

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<sup>109</sup>See Hung (in prep.) for further discussion and an interesting reinterpretation of the final stresslessness phenomenon within Optimality Theory.

(18) FTBIN  $\gg$  PARSE-SYLL, from *hinóki*

Candidates	FTBIN	PARSE-SYLL
☞ (hinó)ki		*
(hi)(nóki)	* !	

The failed candidate in (18) also posits a non-optimal trochee, but irrelevantly, because FT-FORM is ranked below PARSE-SYLL (v. (17)). As in the Suffix-level phonology, Word-level FTBIN is undominated and therefore unviolated in Axininca Campa.

On the evidence presented so far, the Word-level phonology of stress is as follows:

(19) Ranking of Stress Constraints (Preliminary)

FTBIN  $\gg$  PARSE-SYLL  $\gg$  FT-FORM

NONFINALITY  $\gg$  FT-FORM

This system of constraints will determine all aspects of Axininca stress that we have discussed up to this point. A particularly striking result is that the apparent left-to-right directionality of Ft-parsing — a familiar feature of iambic prosody — emerges as a consequence of satisfying both NONFINALITY and FT-FORM, rather than from a rule of iterative foot assignment. To see this, consider first words which consist of strings of light syllables. If the string is of even length, right-to-left ( $\leftarrow$ RL) and left-to-right (LR $\rightarrow$ ) parsing agree with PARSE-SYLL that all syllables are simply paired off in the only way possible: (LL)(LL)... The interesting distinction shows up in odd-length strings. This is seen in (20), where the typical effect attributed to directionality is visible:

(20) Apparent Directionality, from *hinóki*

Candidates	NONFINALITY	PARSE-SYLL	FT-FORM
☞ (hinó)ki		*	
hi(nokí)	* !	*	
hi(nóki)		*	* !

All odd-length candidates respecting the undominated constraint FTBIN necessarily violate PARSE-SYLL, leaving one syllable out of the foot-parse, as (20) exemplifies. Candidates with the *initial* syllable unfooted — equivalent to right-to-left parsing — violate either NONFINALITY or FT-FORM. Candidates with the final syllable unfooted meet both of these constraints, violating only PARSE-SYLL, but violating it no more than any other binary parse. This reasoning clearly holds for all words  $L^m$ ,  $m$  odd. For these, then, the given hierarchy yields the effect of LR $\rightarrow$ -parsing, without however parsing in any direction.

To establish that the result holds true for all words, no matter what their array of heavy and light syllables, we observe that any string can be analyzed into segments  $L^m$ ,  $L^mH$ ,  $H$ , where

these are chosen to be of maximal size, so that a segment  $L^m H$  is not preceded by  $L$ , and any segment  $L^m$  is neither preceded by  $L$  nor followed by  $L$  or  $H$  (in the latter case, we'd go for the  $L^m H$  analysis). Thus, a segment  $L^m$  must be the *last* syllable string in the word, so that we are looking at  $\#L^m\#$  or  $\#...HL^m\#$ . For such an  $L^m$ , an argument like that just given for (20) establishes that the  $L$ -string is parsed in the “left-to-right” fashion, leaving a final  $L$  loose if and only if  $m$  is odd. So  $L^m\# = Ft^k\langle L \rangle\#$ . Consider  $L^m H$  now. If  $m$  is even, the  $L$ -string will always be paired up completely, in satisfaction of PARSE-SYLL, paralleling  $LR \rightarrow$  parsing and contradicting  $\leftarrow RL$  parsing. Furthermore, the  $H$  at the end will be a monosyllabic foot. This shows that  $L^m H$  is prosodically closed:  $L^m H = Ft^k$ ,  $m$  even. Suppose now that  $m$  is odd. Here  $LR \rightarrow$ ,  $\leftarrow RL$ , and PARSE-SYLL all agree: in  $L^m H$ , the final  $H$  captures the  $L$  that precedes it, and the remaining even-length sequence  $L^{m-1}$  is completely paired up. Here again the sequence is prosodically closed:  $L^m H = Ft^k$ . It remains to account for the syllables analyzed as belonging to segments  $H$ ; these are not preceded by  $L$ , so they must be monosyllabic feet. Hence, they are prosodically closed as well. Putting all this together, we have shown that any word can be analyzed into segments that, excepting possibly the last  $L^m$ , consist of an integral number of feet. Each such segment, and therefore the whole word, is parsed by the constraint hierarchy into a structure identical to that achieved with  $LR \rightarrow$  directional parsing. Thus, final stresslessness and the requirement of exhaustive footing lead to the appearance of left-to-right directionality in iambic systems.

Following the Optimality-Theoretic imperative to derange all the senses of ranking,<sup>110</sup> consider what happens when FT-FORM dominates NONFINALITY. The only case where this will make a difference is  $L^m$ , which is the same as  $L^m\#$ ; this is the segment where nonfinality comes into play. If  $m$  is odd, both FT-FORM and NONFINALITY are satisfied by leaving the final syllable unfooted, so  $L^m = L^{m-1}\langle L \rangle$ , in the  $LR \rightarrow$  manner. If  $m$  is even, then PARSE-SYLL wants complete pairing, and the dominance of FT-FORM over NONFINALITY ensures that the last foot, like all the others, is iambic. A language like this is Creek (Haas 1977, McCarthy 1979b). Thus, if we uphold FTBIN and PARSE-SYLL as undominated, so that feet are minimally bimoraic and the rhythm is as tightly packed as possible, we may vary the ranking of FT-FORM and NONFINALITY to generate the iambic systems. There is no directionality of parsing, and only the “left-to-right” pattern is obtained. We have, then, a new explanation for iambic left-to-rightness, making crucial use of Optimality Theory and of the LH foot.<sup>111</sup>

In the examples discussed so far, the final syllable is light, so stresslessness is unproblematic. But heavy syllables have a strong universal association with stress, incorporated into the Weight-to-Stress Principle (WSP) of Prince (1991):

(21) WSP

A heavy syllable is stressed.

The tension between final stresslessness and WSP is an important force in the phonology of many languages (Prince and Smolensky 1992, 1993; Hung 1992; Itô and Mester 1992), Axininca Campa among them.

<sup>110</sup>*Vulgo*: in OT, permuted rankings should also give possible languages.

<sup>111</sup>Contrast this account with that of Kager (1992c), who argues for strictly bimoraic feet and directionality.

WSP is undominated in Axininca Campa. The effect of this may be seen in words ending in heavy syllables, all of which are in fact diphthongal.<sup>112</sup>

(22) Final Diphthongs

(kiti)(šità)(kotái)	‘la mañana les sobrevino’
(àa)(tái)	‘iremos’

The constraints WSP and NONFINALITY conflict in words like this. The options are to violate either WSP, with a stressless final H, or NONFINALITY, with a stressed final H. The fact that final diphthongs *are* stressed shows that WSP is dominant:

(23) WSP  $\gg$  NONFINALITY, from *kitišitàkotái*

Candidates	WSP	NONFINALITY
☞ (kiti)(šità)(kotái)		*
(kiti)(šitá)(kòtai)	* !	

The failed candidate in (23) also violates FT-FORM, but irrelevantly, since FT-FORM ranks below NONFINALITY.

Another logically possible option is to parse the final syllable as light, thereby satisfying both WSP and NONFINALITY:

(24) \*(kiti)(šitá)(kòta⟨i⟩)  
 \*(kiti)(šitá)(kòt⟨a⟩i)

But nonincorporation of a vowel is barred by PARSE-*seg*, which is undominated at Word level, just as it is at Suffix level. (A fully-parsed diphthong is heavy in Axininca Campa — see §2.3.) PARSE-*seg* also compels violation of NONFINALITY in the small set of CVV monosyllables like reduplicated *ii*//*iiwaitaki* ‘has continued to be named more and more’ or the nouns in (25) (cf. Spring 1990b, McCarthy and Prince 1991a).

(25) Final Length in CVV Monosyllables

míi	‘otter’
sóo	‘sloth’
šáa	‘anteater’

The only alternative to final-stressed (*míi*) is ⟨*mii*⟩, in which no foot is posited at all. In this form, though, no segments at all are parsed, since without a foot there can be no Prosodic Word, as

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<sup>112</sup>Even diphthongal syllables are stressless *phrase*-finally (Payne, Payne, and Santos 1982:188).

required by the Prosodic Hierarchy (v. §4.3). Violation of undominated *PARSE-seg* is fatal for  $\langle mii \rangle$ , and with FTBIN undominated too the minimal PrWd is a bimoraic monopod like *mii*.<sup>113</sup>

But final long vowels in polysyllables can be parsed as light without violating *PARSE-seg*, and this does indeed happen. It has already been seen in the example *api* $\langle i \rangle$ //*apiiwaitaki* ((54) in §5.4). Alternations between long non-final vowels and short final ones are richly attested in nouns:

(26) Final Shortness

	Noun	‘my’+Noun	
/sampa/	sampa $\langle a \rangle$	no-sampa-ti	‘balsa’
/sawoo/	sawoo $\langle o \rangle$	no-sawoo-ti	‘case’
/c <sup>h</sup> imii/	c <sup>h</sup> imi $\langle i \rangle$	no-c <sup>h</sup> imii-ti	‘ant’
Compare			
/sima/	sima	no-sima-ni	‘fish’
/čokori/	čokori	no-čokori-ti	‘armadillo’

In forms like *sampa* $\langle a \rangle$ , the final mora is unparsed, as indicated by the brackets  $\langle a \rangle$ . This incurs a violation of *PARSE- $\mu$*  (§2.2), though not of *PARSE-seg*, since the **melodeme** *a* is still parsed by the other mora of its syllable. Cross-linguistically, it is a frequent situation to find *PARSE- $\mu$*  violated in optimal forms where *PARSE-seg* is not — this is the basis of the common “closed-syllable shortening” phenomenon.

Parsing a final long vowel as short incurs a violation of low-ranking *PARSE- $\mu$* , but satisfies both *WSP* and *NONFINALITY*, an interaction first proposed in Hung (1992, in prep.):

(27) Final Shortness, from /apii/

Candidates	WSP	NONFINALITY	PARSE- $\mu$	FT-FORM
(apii)		* !		
(ápii)	* !			*
 (ápi) $\langle i \rangle$			*	*

The actual output form *ápi* $\langle i \rangle$  violates both of the lower-ranking constraints, but it is the only one of the candidates to obey both of the higher-ranking constraints. In this way, the stresslessness of final syllables entails their shortness, as Hung argues.

This brings us at last to a final ranking argument: the relation between *NONFINALITY* and *PARSE-SYLL*. The crucial test case is a word ending L<sup>m</sup>H, where H is an underlying long vowel. The string-segment L<sup>m</sup>H is, as noted above, susceptible to a complete parse into an integral number of feet, satisfying *PARSE-SYLL*; but this parse stresses the final syllable in violation of

<sup>113</sup>Though words like *mii* occur in Axininca Campa, they are rare. Prince and Smolensky (1993) provide an explanation for this scarcity in terms of lexicon optimization. If lexical entries are chosen so as to minimize the constraint violations in surface forms, it is only a small step to suggesting that some lexical entries might be actually avoided because they inevitably lead to constraint-violating surface forms.

NONFINALITY. If, however, the H is realized as L due to failure to parse one of its moras, then for  $m$  even, we will end up with an unparsed surface L at the end of the word, satisfying NONFINALITY but violating PARSE-SYLL. Thus, for strings ending  $L^mH$ ,  $m$  even, final stresslessness can be fairly matched against exhaustive Ft-parsing. An example of this type is *howáma*⟨*a*⟩ (from /howamaɤa/ — see §A.3 below), which establishes that NONFINALITY dominates PARSE-SYLL:

(28) NONFINALITY  $\gg$  PARSE-SYLL, from *howáma*⟨*a*⟩

Candidates	NONFINALITY	PARSE-SYLL
☞ (howá)ma⟨a⟩		*
(howà)(máa)	* !	

Though the actual output form *howáma*⟨*a*⟩ also violates PARSE- $\mu$ , that constraint is irrelevant, since it too is ranked below NONFINALITY.

The Word-level rankings we have established and their effects are as follows:

(29) New Rankings

Rankings	Effects
FTBIN $\gg$ PARSE-SYLL	Incomplete Ft-parse rather than degenerate feet (18)
PARSE- <i>seg</i> $\gg$ NONFINALITY	Final stress rather than diphthong simplification (24). Final stress in monosyllables (25).
WSP $\gg$ NONFINALITY	Final heavy syllables stressed, not stressless (23).
NONFINALITY $\gg$ PARSE- $\mu$	Final stresslessness rather than faithful parse of final long vowels (27).
NONFINALITY $\gg$ FT-FORM	Trochaic word-final foot (16), (17). Free syllable at end of $L^m\#$ , $m$ odd (20).
PARSE-SYLL $\gg$ FT-FORM	Exhaustive footing of even-parity words (17).
NONFINALITY $\gg$ PARSE-SYLL	Final heavy parsed as light and unfooted rather than heavy and footed (28).

This does not yield a total ordering of all the constraints, but collecting the unviolated ones into a single block at the top, we obtain the hierarchy in (30).

## (30) Word-Level Constraint Hierarchy (Stress-related)

FTBIN  
 WSP  
 PARSE-*seg*  
 >>  
 NONFINALITY  
 >>  
 PARSE-SYLL  
 >>  
 FT-FORM  
 PARSE- $\mu$

The constraints FTBIN and WSP reflect fundamental properties of stress theory; their status as unviolated constraints is observed in many languages other than Axininca Campa, and may be universal or nearly so. PARSE-*seg* is unviolated in the Axininca Suffix-level phonology just as it is in the Word-level phonology. Violation of PARSE-*seg* in this language is limited to the Prefix level, and it may in fact be allomorphic rather than phonological (v. §3). The dominated constraints are also a familiar lot, typical of stress systems in general and of iambic stress in particular. (See Prince and Smolensky 1993:§4, Hung (in prep.) for discussion.)

What is the relation between this Word-level constraint hierarchy and the Suffix-level constraint hierarchy, summarized above in §5.5 (75)? As noted, the undominated constraints FTBIN and PARSE-*seg* hold sway at the top of both hierarchies, establishing one point of intersection. Another, more interesting point of intersection can be determined by considering the consequences of FILL-violation for the dominated stress-constraints NONFINALITY and PARSE-SYLL:

## (31) FILL &gt;&gt;NONFINALITY, from (kiti)(šità)(kotái) (cf. (23))

Candidates	FILL	NONFINALITY
☞ (kiti)(šità)(kotái)		*
(kiti)(šità)(kotái)TA	* ! *	

## (32) FILL &gt;&gt;PARSE-SYLL, from (hinó)ki (cf. (18))

Candidates	FILL	PARSE-SYLL
☞ (hinó)ki		*
(hinó)(kíTA)	* ! *	

Clearly, the requirements of final stresslessness and exhaustive Ft-parsing are not to be met by positing additional epenthetic syllables. This shows that FILL dominates NONFINALITY and, by direct argument as well as transitivity of >>, that FILL dominates PARSE-SYLL. Thus, also by transitivity of >>, all of the dominated constraints of the Word-level system are ranked below

FILL.

But FILL is a crucial nexus for constraint domination relations; it is the lowest-ranking phonological constraint of the Suffix-level hierarchy; all lower-ranking constraints pertain only to the well-formedness of the Reduplicant. It is therefore easy to see how the stress constraints could be merged with the Suffix-level constraints into a single Suffix-level constraint system:

(33) Suffix-level Constraint Hierarchy (Stress constraints added)

	ONSET, CODA-COND, etc.	
	FTBIN, PARSE- <i>seg</i> , etc.	
	WSP	
	>>	
	ALIGN, SFX-TO-PRWD	
	>>	
	FILL	
	>>	
NONFINALITY		DISYLL
>>		>>
PARSE-SYLL		R=SFX, R≤ROOT
>>		>>
FT-FORM		MAX
PARSE- $\mu$		

What we are proposing is that all of the stress constraints of the Word-level phonology are immanent in the Suffix-level system. Shortly, we will demonstrate that this permits a very simple characterization of how the Suffix-level and Word-level constraint hierarchies differ; but first we must show that the fusion of the two systems in (33) leads to no untoward effects in the Suffix-level phonology.

Ranked below FILL as they are, the dominated stress constraints can have only very limited effect in the Suffix-level phonology. They cannot compel epenthesis, as shown in (31, 32). Furthermore, the final vowel shortening phenomenon observed at Word level (26) is impossible at Suffix level without violating dominant ALIGN:<sup>114</sup>

(34) Unparsed Final  $\mu$  Violates ALIGN

sam.pa.⟨a⟩|

Therefore PrWd-final syllables must be faithfully parsed in the Suffix-level phonology, though they may not be faithfully parsed at Word level.

Inclusion of the stress constraints in the Suffix-level system will, of course, require that all forms be parsed with foot structure in the Suffix-level phonology. As we argued in §A.1, this is essential to the explanation for augmentation. But because they are ranked below SFX-TO-PRWD, the stress constraints must bend to the requirements of any PrWd posited at the left edge of a suffix. This is shown by the example (35), which repeats (3) from §A.1:

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<sup>114</sup>The length of the final vowel is part of the lexical representation of /sampa/; thus, failure to parse it fully is a violation of ALIGN. See the discussion of (45) in §4.3.2.

(35) Suffix-level Ft Parse (cf. (iii) in §A.1)

- a. [[[ (nomà) na ]–(pit<sup>h</sup>à)(čáa) ] –ri]  
 b. [[ (nomà)(na–pì)(t<sup>h</sup>ačáa) ] –ri]

In (35a), the underlined syllable *na* cannot be included in the Ft-parse without violating SFX-TO-PRWD. Since SFX-TO-PRWD dominates PARSE-SYLL at Suffix level, (35a) rather than (35b) is the output of the Suffix-level phonology.

As noted in §A.1, the foot-parsing (35a) is not surface-true, since the recursive PrWd structure is not respected by the Word-level foot-parse. The explanation for this is also laid out in §A.1: the deforestation of Bracket Erasure. Incorrect Ft-parsings like (35a) represent only a temporary commitment of the phonology, one that is supplanted on the next round in the Word-level phonology.

To sum up, we have shown that incorporation of the stress constraints into the Suffix-level phonology can have almost no visible effect, because they are crucially ranked below the faithfulness constraint FILL. Indeed, the only possible consequence of this move is to include foot structure in the output of Suffix level, as required by the augmentation facts (2). Since Suffix-level Ft-parsing does not conform to the observed Word-level stress system, we stipulate that no foot structure is inherited from Suffix level to Word level, thanks to the ministrations of Bracket Erasure.

Apart from increasing the formal homogeneity of the constraint system, this move leads to a particularly attractive treatment of the difference between the Suffix-level and Word-level constraint systems. Specifically, the entire difference between the Suffix-level and Word-level constraint systems can be localized in the ranking of the two interface constraints ALIGN and SFX-TO-PRWD. Final shortening effects show that ALIGN may be violated freely at Word level (34); violation is compelled by NONFINALITY. Since (35b) is the Word-level foot parse, SFX-TO-PRWD is also freely violated at Word level; violation is compelled by PARSE-SYLL. Thus, the full Word-level constraint hierarchy (minus the reduplicative constraints, which are irrelevant), is as follows:

(36) Word Level Constraint Hierarchy (Preliminary)

ONSET, CODA-COND, etc.  
 FTBIN, PARSE-*seg*, etc.  
 WSP  
 >>  
 FILL  
 >>  
 NONFINALITY  
 >>  
 PARSE-SYLL  
 >>  
 FT-FORM, PARSE- $\mu$   
 ALIGN, SFX-TO-PRWD

None of the lowest-ranking constraints is rankable with respect to the others. But the crucial

move is fully justified: ALIGN and SFX-TO-PRWD rank below the Ft-parsing constraints NONFINALITY and PARSE-SYLL. This is the sole difference between the Suffix-level and Word-level phonologies.

This result is a particularly attractive one, because it establishes an abstract connection between our Optimality-Theoretic analysis of Axininca Campa and some of the fundamental observations underlying the theory of Lexical Phonology (e.g., Kiparsky 1982, Mohanan 1982, Borowsky 1986).<sup>115</sup> Among the syndrome of properties said to characterize rules of the **lexical** phonology are *cyclicity* and *sensitivity to morpheme identity*; in contrast, rules of the post-lexical phonology are claimed not to have these properties. In a rule-based framework like Lexical Phonology, cyclic rule application and sensitivity to morpheme identity in rules are analogous to interface constraints like ALIGN and SFX-TO-PRWD. (In fact, the same observations motivating ALIGN have been seen as evidence of cyclic rule application in the literature; v. §4.2.) Thus, to the degree that the lexical syndrome holds up under empirical skepticism, it should be mimicked in Optimality Theory by the demotion of interface constraints between lexical and post-lexical levels. And that is precisely the distinction we have noted between the Suffix-level and the Word-level phonologies of Axininca Campa.

Of course, the observed demotion of two interface constraints in the Axininca Word level does not precisely simulate the distinction between lexical and post-lexical rules in Lexical Phonology. Indeed, the interface constraint ALIGN-L is unviolated at Word level as it is at suffix level, and another, RT-SFX-SEGREGATION, discussed below in §A.3, is visibly active only at Word level. But an exact simulation is not called for; all current conceptions of Lexical Phonology accept that the lexical syndrome is no more than a rough approximation to the truth. Rather, what is appropriate and what we in fact have here is an abstract correlation between two very different conceptions of linguistic structure. Exploration of the differences and testing against further data are obvious tasks for the future.

### A.3. Velar Glide Loss

From stress we turn to another major phenomenon of Axininca Campa, the loss of the velar glide  $\upsilon$ . The conditions under which  $\upsilon$  is lost or retained have been the object of much analytic and theoretical attention, beginning as usual with Payne (1981) and continuing with Yip (1983), Black (1991a), and Spring (1991). A matter of particular interest, which we take up at the end, is the prosody/morphology interface condition on velar glide loss that is the focus of Black (1991a) and Spring (1991).

As noted in §A.1 above, when the velar glide  $\upsilon$  is adjoined on both sides by light syllables, it is normally absent, with the result that the abutting vowels are fused into a single heavy syllable:

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<sup>115</sup>We are grateful to Junko Itô, Armin Mester, and Jaye Padgett for challenging us on a related point.

## (37) Velar Glide Loss in Light-Light Context

/ic <sup>h</sup> inau <sub>ɰ</sub> iro/	ic <sup>h</sup> ina <sub>ɰ</sub> iro	‘he raised it’
/hau <sub>ɰ</sub> akiro/	ha <sub>ɰ</sub> akiro	‘he has taken it’
/ita <sub>ɰ</sub> akiro/	ita <sub>ɰ</sub> akiro	‘he has burned it’
/hira <sub>ɰ</sub> antawori/	hira <sub>ɰ</sub> antawori	‘(reason) that he mourned it’
/na <sub>ɰ</sub> ana <sub>ɰ</sub> awaitaki/	na <sub>ɰ</sub> ana <sub>ɰ</sub> awaitaki	‘I will continue to take more and more’
/au <sub>ɰ</sub> a <sub>ɰ</sub> awaitaki/	aa <sub>ɰ</sub> awaitaki	‘has continued to take more and more’
/onta <sub>ɰ</sub> awaitiroota/	onta <sub>ɰ</sub> awaitiroota	‘she might continually burn it’

Recall that epenthetic vowels are fully spelled-out prior to Word level, so the underlying representations in (37) do not indicate the more remote origins of the sequence /...u<sub>ɰ</sub>ΔC.../ from /...u<sub>ɰ</sub>-C.../, as in the last example.

When one or both of the abutting syllables is heavy, though, the velar glide is preserved:

## (38) Velar Glide Preservation in Light-Heavy, Heavy-Light, or Heavy-Heavy Context

<i>Context</i>	<i>Input</i>	<i>Output</i>	<i>Gloss</i>
LH	/ta <sub>ɰ</sub> aanc <sup>h</sup> i/	ta <sub>ɰ</sub> aanc <sup>h</sup> i	‘to burn’
LH	/ita <sub>ɰ</sub> aiyironi/	ita <sub>ɰ</sub> aiyironi	‘they burned it’
HL	/hoya <sub>ɰ</sub> akiro/	hoya <sub>ɰ</sub> akiro	‘he has inserted it’
HL	/oya <sub>ɰ</sub> awaitiroota/	oya <sub>ɰ</sub> awaitiroota	‘she might continually insert it’
HH	/oya <sub>ɰ</sub> aanc <sup>h</sup> i/	oya <sub>ɰ</sub> aanc <sup>h</sup> i	‘to insert’

Payne (1981:71) explains this basic contrast as follows: the velar glide “is lost in any ... environment which can afford to lose it, i.e. where it will not yield an unacceptable vowel cluster”. Subsequent analysts concur that the preservation of the velar glide in (38) follows syllabic well-formedness constraints (Yip 1983, Black 1991a, Spring 1991).

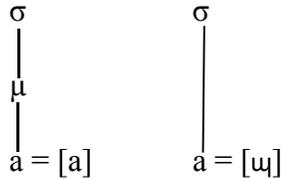
There are two basic prosodic effects to be dealt with: loss of the velar glide between light syllables, as in *haakiro* from /hau<sub>ɰ</sub>-akiro/, and retention of the velar glide adjacent to a heavy syllable, as in *ta<sub>ɰ</sub>aanc<sup>h</sup>i*. There are also two basic segmental effects: the mere fact of loss of the velar glide (when PARSE-*seg* is otherwise unviolated) and the fusion of formerly separate vowels into a single long vowel. We will deal with the segmental matters first, then the prosodic ones.

The fundamental segmental problem is this: how is velar glide loss possible at all without violating the undominated constraint PARSE-*seg*? Related to this is the problem of why velar glides should be lost at all; what universal constraint do they violate? A final issue, connected to the first two, concerns the analysis of *howama*⟨*a*⟩ (28), which derives from /howama<sub>ɰ</sub>/; for this form to violate PARSE-*μ* but not PARSE-*seg*, it is necessary for the input /howama<sub>ɰ</sub>/ to have a single *a* melodeme shared between the last two syllables. If these two *as* were melodically separate, this form would violate PARSE-*seg*, and so it would be in principle indistinguishable from \**impoka*⟨*i*⟩ (24). To put it differently, the product of velar glide loss between *as* is phonologically indistinguishable from an underlying long *a*:

All of these issues are resolved with a proper understanding of the representation of the velar glide. Payne (1981: 71) notes that u<sub>ɰ</sub> and *a* are very similar phonetically, and on the strength of this similarity Yip (1983) and Black (1991a) propose that u<sub>ɰ</sub> is simply the glide corresponding to *a*, so u<sub>ɰ</sub> and *a* are featurally identical but differ in syllabificational or moraic status. (Thus, we

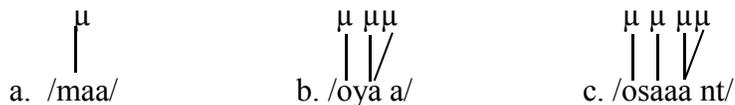
should probably write  $\underset{\mu}{a}$  for  $\underset{\mu}{u}$ .) Formally, we assume that  $\underset{\mu}{u}$  is simply  $a$  linked to  $\sigma$  rather than  $\mu$ .<sup>116</sup>

(39) Representation of  $a$  and  $\underset{\mu}{u}$



In underlying forms, the velar glide and the vowel  $a$  are distinguished by the absence vs. presence of moraic structure (v. §2.3 and Hayes (1989)). In particular, the underlying representations of the roots / $\text{ma}\underset{\mu}{u}$ / ‘sleep’, / $\text{oya}\underset{\mu}{u}$ / ‘insert’, and / $\text{osa}\underset{\mu}{u}\text{aant}$ / ‘stick in to pull out’ are as follows:

(40) Underlying Representation of / $\text{ma}\underset{\mu}{u}$ /, / $\text{oya}\underset{\mu}{u}$ /, / $\text{osa}\underset{\mu}{u}\text{aant}$ /



If the OCP is active in Axininca Campa, it is presumably relativized to the prosodic status of the melodemes involved (Lamontagne 1992), so it does not apply to  $\underset{\mu}{u}$  sequences. More elaborated representations — for example, involving distinct root-nodes and shared place-nodes, as proposed by Black (1991a) — are possible and may even be necessary, but (40) suffices for present purposes.<sup>117</sup>

The constraint motivating velar glide loss can now be seen as a prohibition on the  $a$ -to- $\sigma$  association, or equivalently a limitation of  $a$  to moraic positions:

(41)  $a = \text{VOWEL}$

$a$  is not linked to  $\sigma$ .

This is a very natural constraint that expresses one aspect of the universal preference for high sonority segments in moraic positions (Prince 1983:58, McCarthy and Prince 1986:71, Zec 1988, Rosenthal in prep.). In Berber, for example, the constraint  $a = \text{VOWEL}$  is undominated, so  $a$  is restricted to syllable nuclei, though all other segments of Berber can fill the nucleus or onset role, depending on context (Dell and Elmedlaoui 1985, 1988; Prince and Smolensky 1991b, 1993). Similarly, in Chicano Spanish, hiatus is resolved by parsing the first of two vowels as a glide if

<sup>116</sup>When the velar glide is followed by  $i$ , it is realized as  $y$ : *poyaayiro* ‘you will insert it’ from the root / $\text{oya}\underset{\mu}{u}$ /. We assume that this fully automatic alternation is a phonetic matter, implemented *after* the Word-level phonology. We will therefore abstract away from it in our transcriptions. Indeed, we **must** make this assumption, because / $\underset{\mu}{u}$ / is lost even in contexts where it could be realized as  $y$  (and presumably preserved): / $\text{ic}^{\text{h}}\text{ina}\underset{\mu}{u}\text{-iro}$ / →  $\text{ic}^{\text{h}}\text{inairo}$ , \* $\text{ic}^{\text{h}}\text{inayiro}$ .

<sup>117</sup>A more complex representation may be needed, as Black (1991a) proposes, to account for the fact that / $\underset{\mu}{u}$ / occurs only after / $a$ / in morphemes.

it is *i*, *e*, *o*, or *u*, but by not parsing it at all if it is *a* (Clements and Keyser 1983:85-95). We therefore have an explanation for why velar glides should be lost at all — they contravene a universal constraint on the relation between sonority and moraic or nuclear status.

Recognizing the proper representation of  $\mu$  as non-moraic *a* leads to an explanation for how velar glide loss is possible without violating undominated PARSE-*seg*. Throughout, we have assumed that the function Gen, which generates the set of candidate forms, has complete Freedom of Analysis limited only by Containment, which prohibits the literal removal of any element from the input (§2.3). Suppose now that the Containment requirement is relaxed slightly, so that Gen is free to treat sequences of identical melodic elements as a single melodeme. Since / $\mu$ / is always preceded by /a/ in underlying representation, and since /a/ and / $\mu$ / are melodically identical, this small change in the conception of Gen means that velar glide loss can occur without incurring a violation of PARSE-*seg*.

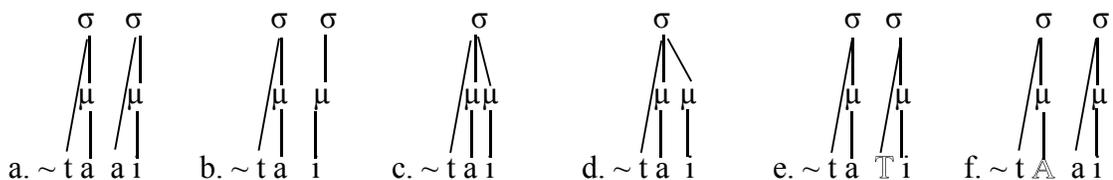
To see how this works, consider first of all a simple example like *imitai*, which emerges from Suffix level as /imita $\mu$ i/:

(42) Suffix-level Output: /imita $\mu$ i/



Ft- and PrWd-level structure have been suppressed, since they represent only a temporary commitment, rendered void by Bracket Erasure. Given this input, Gen is free to posit a variety of output candidates, limited only by the need to preserve moras and non-identical melodeme sequences, in conformity with Containment:

(43) Word-level Candidates: *imitai*

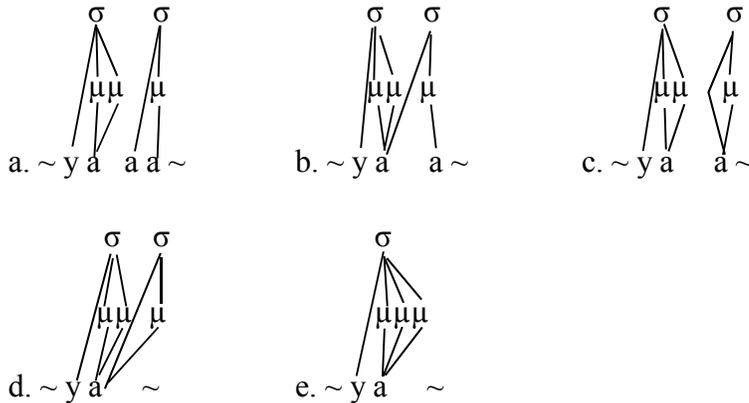


Forms (43a) and (43b) are structurally dissimilar but phonetically identical; we don't need to choose between them because both violate  $a$ =VOWEL, while (43c) obeys it. Forms (43d) and (43e) also obey  $a$ =VOWEL, but they violate other constraints instead: ONSET in the case of (43d), FILL in the case of (43e). The final candidate (43f) violates both FILL and  $a$ =VOWEL, pointlessly. Thus (43c), representing *imitai*, is the actual output, since it obeys all of the relevant constraints.<sup>118,119</sup>

<sup>118</sup>The constraint  $a$ =VOWEL is not visibly active in the Suffix-level phonology; if it were, then velar glides couldn't survive to see Word level, contradicting the argument for Word-level velar glide loss in §A.1. The proximate cause is that the Gen-initiated fusion of /aa/ melodeme sequences takes place at the interface between Suffix level and Word level. The Suffix-level phonology is presented with representations like those in (40), so  $a$ =VOWEL is impotent; though the velar glides in these forms violate  $a$ =VOWEL, they are protected by dominant PARSE-*seg*. In

Considerations of syllable well-formedness will militate against velar glide loss in appropriate circumstances. This is apparent from (44), an assortment of candidates supplied by Gen from the Suffix-level output /*o<sub>y</sub>aa<sub>u</sub>awaitiroota*/:

(44) Word-level Candidates: *o<sub>y</sub>aa<sub>u</sub>awaitiroota*



Under Containment, Gen is committed to respecting the lexically distinctive structure of the input, including moras as well as syllables; hence it will offer a monosyllabic analysis like (44e), which violates the ban on trimoraic syllables (§2.3). Below in (46) we will see that other candidates which respect *a*=VOWEL are, like (44e), barred by dominant constraints. Thus, violation of *a*=VOWEL is necessary, as in (44a-d), all of which are also offered by Gen. Currently, it is uncertain which of these is the correct output, since they will receive identical (and correct) phonetic interpretations, and since they tie on all of the constraints we have discussed. Presumably \*STRUC (§2.3) will select the candidate with the least articulated representation (44d), though typological considerations argue against all except (44a) (Levin 1985:85; Mester 1991). There is an indeterminacy, then, but a relatively harmless one, easily resolved by further cross-linguistic investigation.

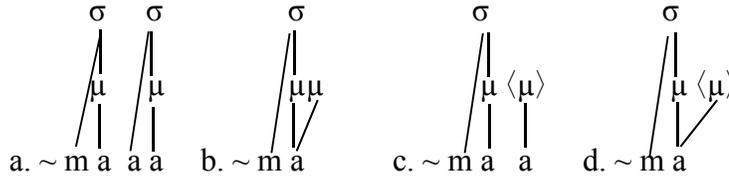
In the case of *howama*⟨*a*⟩ (28), a mora but no melodic material remains unparsed in the output, incurring a violation of low-ranking PARSE- $\mu$ , but not of PARSE-*seg*:

other words, loss of the velar glide is impossible in the Suffix level phonology because the velar glide is melodically independent at that stage and, as usual, PARSE-*seg* is unviolated.

This explanation raises a further question: if the melodic fusion of /aa/ sequences into /a/ is a general property of the interface between levels, why doesn't it occur at the interface between Prefix level and Suffix level, thereby affecting root-final /au/ sequences like those in (40)? There are two possible answers, both along lines mooted in §3. One is that the Prefix level is not a level at all, but a collection of idiosyncratic allomorphy phenomena that provide the input to the Suffix-level phonology. The other is that root-final consonants, including /u/, are generally extrametrical at Prefix level. Recall that root-final consonants, though unsyllabified, are not deleted at the end of Prefix level.

<sup>119</sup>The constraint *a*=VOWEL does not interact crucially with the interface constraints ALIGN or SFX-TO-PRWD. As was observed in §4.2, a C-final stem must always violate ALIGN. Thus, a form like /imitau-i/ violates ALIGN whether the u is present or not: *i.mi.ta|i*, \**i.mi.ta.u|i*. Loss of the velar glide is mora-conserving, so it does not affect the satisfaction of FTBIN and, by extension, SFX-TO-PRWD. This can be seen in the following comparison (from the PrWd-compound /aua||auawaitaki/): *aa||waitaki*, \**aua||waitaki*.

(45) Word-level Candidates: *howama*⟨a⟩ from /howamaʷa/



The constraint  $a=\text{VOWEL}$  banishes (45a), while WSP and NONFINALITY exclude (45b) (v. (28)). In the remaining candidates, the final syllable is light, by virtue of violating  $\text{PARSE-}\mu$ . In (45c), though,  $\text{PARSE-seg}$  is violated as well, with deadly consequences. Thus, the actual output is (45d), which violates only low-ranking  $\text{PARSE-}\mu$ . In this way, the product of velar glide loss may have exactly the phonology of an underlying long vowel, and so participate in the final shortening phenomenon.

In summary, a proper understanding of the representation of /ʷ/ and the role of Gen resolves all of the segmental issues we have raised. Loss of the velar glide is possible in the Word-level phonology because the velar glide is not necessarily melodically independent at that stage; a missing velar glide doesn't always mean an unparsed melodeme. The combination of shortening and velar glide loss in *howama*⟨a⟩ also obeys  $\text{PARSE-seg}$ , because original /aʷa/ is parsed, melody-wise, as a single segment. Long vowels resulting from velar glide loss have exactly the representation of all other long vowels: as a single melodeme linked to two moras.

We turn now from the segmental phonology of the velar glide to the prosodic phonology. As we have noted, the velar glide is retained when the alternative candidates violate one or more of the requirements of syllable well-formedness or faithfulness. For example, though *ta.ʷaan.c<sup>hi</sup>* violates  $a=\text{VOWEL}$ , all the competing candidates violate other constraints:

\**ta.aan.c<sup>hi</sup>* violates ONSET.

\**taa*⟨a⟩*n.c<sup>hi</sup>* has an unparsed mora, violating  $\text{PARSE-medial-}\mu$ .<sup>120</sup>

\**taaan.c<sup>hi</sup>* violates syllable bimoraicity (§2.3).

\**ta.Taan.c<sup>hi</sup>* violates FILL.

FILL is the lowest-ranking constraint in the batch (it is the only dominated one), so the  $\text{FILL} \gg a=\text{VOWEL}$  ranking argument is the most useful one:

(46)  $\text{FILL} \gg a=\text{VOWEL}$ , from /taʷaanc<sup>hi</sup>/

Candidates	FILL	$a=\text{VOWEL}$
taʷaanc <sup>hi</sup>		*
taTaan <sup>hi</sup>	* !	

<sup>120</sup>PrWd-medial moras must be parsed, whereas PrWd-final ones may be parsed or not, to suit the exigencies of Ft-parsing. Lacking anything more penetrating to say at the moment, we assume distinct constraints  $\text{PARSE-medial-}\mu$  and  $\text{PARSE-final-}\mu$  (the latter called just  $\text{PARSE-}\mu$  in the text).  $\text{PARSE-medial-}\mu$  is undominated, but  $\text{PARSE-final-}\mu$  is low-ranking, as (36) shows.

Since  $a=VOWEL$  is ranked below  $FILL$ , it must also be ranked below all other constraints on syllabic well-formedness and faithfulness (see §A.2). In this way we capture Payne's basic insight that  $\omega$  "is lost in any ... environment which can afford to lose it".

The ranking argument (46) places an upper bound on  $a=VOWEL$ 's place in the constraint hierarchy. The treatment of  $\omega$  in the onset of a word-final syllable places a lower bound on its ranking, through interaction with  $NONFINALITY$ . There are three cases to consider:

(47) Velar Glide Loss in Final Syllables

a. Between Identical Vowels

/ic <sup>h</sup> ina $\omega$ -a/	ic <sup>h</sup> ina⟨a⟩	'he lifted his body part'
/howama $\omega$ -a/	howáma⟨a⟩	'he killed himself'

b. In Bimoraic PrWds

/aua  a $\omega$ awaitaki/	aa  aawaitaki	'has continued to take more and more'
----------------------------	---------------	---------------------------------------

c. Between  $a$  and  $i$

/imita $\omega$ -i/	imitái	'he jumped'
/ampoka $\omega$ -i/	ampokái	'we will come back'

In all three cases, the forms with velar glides receive the same disposition as words that end in an underlying long vowel or diphthong: the final heavy syllable is parsed as light (47a), satisfying  $NONFINALITY$  and  $WSP$ , unless the word is monosyllabic (47b) or diphthong-final (47c).

Because final diphthongs must be stressed, in violation of  $NONFINALITY$ , case (47c) supplies the necessary argument for the ranking of  $a=VOWEL$  relative to the stress constraints:

(48)  $a=VOWEL \gg NONFINALITY$ , from  $(imì)(tái)$

Candidates	$a=VOWEL$	$NONFINALITY$
☞ (imì)(tái)		*
(imí)(tàuì)	* !	

Since  $NONFINALITY$  is the highest-ranking constraint of the stress system, this argument certifies that  $a=VOWEL$  also dominates all the other constraints introduced in §A.2 (except for undominated ones, of course). From this, the transparent interaction between velar glide loss and the rest of the Word-level phonology, observed in (47), follows automatically. We include the tableaux here for completeness:

(49) /howamaɥa/

Candidates	<i>a</i> =VOWEL	NONFINALITY	PARSE-SYLL	FT-FORM	PARSE- $\mu$
howá)(màɥa)	*!			*	
(howà)(máa)		*!			
☞ (howá)ma⟨a⟩			*		*

(50) /aɥa/

Candidates	<i>a</i> =VOWEL	NONFINALITY	FT-FORM
(aɥá)	*!	*	
(áɥa)	*!		*
☞ (áa)		*	

(51) /imitaɥi/

Candidates	PARSE- <i>seg</i>	<i>a</i> =VOWEL	NONFINALITY
(imi)(táɥi)		*!	
☞ (imi)(tái)			*
(imi)ta⟨i⟩ (imi)t⟨a⟩i	*!		

The faithfulness and syllabic well-formedness constraints are not the only ones that must dominate *a*=VOWEL. There is one other circumstance where  $\mathfrak{u}$  is preserved, even though all the conditions for loss are met. As Black (1991a) and Spring (1991) observe, the velar glide is retained when it is the final consonant of a “short” root followed by a –V suffix. An apparently exhaustive list of attested forms displaying this behavior appears in (52); the only –V suffixes are –*i* ‘future/nonfuture’ and –*a* ‘reflexive/nonfuture’.

(52) Retention of  $\omega$  With Short Roots

Root	Suffixed Form <sup>121</sup>	
/au/	nau <i>i</i>	‘I will take’
	nau <i>iri</i>	‘that I will take’
	hau <i>iro</i>	‘he took it’
/tau/	itau <i>a</i>	‘he burned himself’
	itau <i>iro</i>	‘he burned it’
/mau/	amau <i>i</i>	‘we will sleep’
/irau/	hirau <i>a</i>	‘he cried for himself’
	irau <i>a</i>	‘she cried’ (Black 1991a:209)
	irau <i>iro</i>	‘he mourned it’

The conditions for retention of the velar glide are very precise:

- i. **Root Size.** The *root* must be monosyllabic, /V $\omega$ / or /CV $\omega$ /. (We discuss the unique /VCV $\omega$ / root *irau* below.) In longer roots, the velar glide is lost: *imitai* ‘he jumped’ from the root /mitau/ or *ic<sup>h</sup>inairo* from the root /c<sup>h</sup>inau/. It is irrelevant whether or not the root is prefixed in the stem.
- ii. **Suffix Size.** The suffix must be -V. If the suffix is -VC, the velar glide is lost: *itaukiro* ‘he burned it’ from /tau/ with suffix -*ak*.
- iii. **Suffix Status of V.** The vowel following the glide must be suffixal. If the following vowel is epenthetic, the velar glide is lost (Spring 1991): *naa* and *aa* from root /au/ plus epenthetic *a* in the reduplicated forms *naanaawaitaki* and *aa//aawaitaki*.
- iv. **Root Status of  $\omega$ .** The velar glide must be part of a root. If it is part of a suffix, it is lost (Spring 1991): *ampokai* from /ampok- $\omega$ -i/ ‘we’ll come back’, *aanairi* from /au $\omega$ - $\omega$ -i-ri/.

The challenge, then, is to make sense of the conditions under which  $a$ =VOWEL is overridden by some dominant constraint.

Previous treatments of this phenomenon rely on some notion of word minimality, as the classification of roots into “short” and “long” categories would suggest. Black (1991a) has analyzed this minimality requirement in purely **phonological** terms, but Spring (1991) observes that this analysis cannot account for either of condition (iii) or condition (iv), since both refer to the **morphological** status of  $\omega$  and V.

Instead, Spring (1991) proposes a partly morphological explanation for (52). She identifies the suffixes that block velar glide deletion (-*i* ‘future/nonfuture’ and -*a* ‘reflexive/nonfuture’) not by their phonological shape, -V, but by their morphological function, Tense. The core proposal is that Tense subcategorizes for a root that is a PrWd, which entails that the root contain a branching foot to satisfy FTBIN and the Prosodic Hierarchy. Short roots like /tau/ contain just a single mora plus a degenerate syllable assigned to the final consonant. Spring proposes that this is just sufficient to satisfy FTBIN, exactly matching but not exceeding the subcategorizational requirement imposed by Tense. In order to block the phonological rule of velar glide deletion, this subcategorizational requirement must be assumed to apply not only at lexical insertion but persistently, throughout the derivation. Thus, the derivation of \**tai* from /tau-i/ is blocked because the monomoraic root remnant *ta* within \**tai* does not satisfy the

<sup>121</sup>Recall that  $\omega$  is realized as *y* before *i* and that the forms cited abstract away from this alternation.

subcategorizational requirement imposed by Tense, but /mitau<sub>ɥ</sub>-i/ becomes *mitai* because the bimoraic root remnant *mita* does satisfy the subcategorized PrWd.

This analysis is successful descriptively, accounting for all of the fairly elaborate prerequisites to blocking velar glide loss. Because the analysis refers directly to the morphological notion Root, it accounts for why root size alone matters and why suffixal  $\mathfrak{u}$  is deleted freely. Because it also refers (indirectly) to the morphological notion Suffix, it accounts for why only suffixal vowels, and not epenthetic *a*, will trigger velar glide deletion. This analysis identifies the class of suffixes blocking velar glide deletion in morphological terms — they mark Tense — though it would be preferable to identify them phonologically, as –V. The account we will now propose does exactly that.

Consider again the basic contrast underlying the **Root Size** observation (i). This is the contrast between *itau<sub>ɥ</sub>i* (and *\*itai*) from the root /tau<sub>ɥ</sub>/ and *imitai* from the root /mitau<sub>ɥ</sub>/:

(53) *itau<sub>ɥ</sub>i/imitai* Contrast

	<i>Morphological Analysis</i>	<i>Prosodic Analysis</i>	<i>Joint Analysis</i>
a.	i-tau <sub>ɥ</sub> -i	.i.ta.ɥi. *i.tai.	.i-.ta.ɥ-i. *i- <u>ta-i</u> .
b.	i-mitau <sub>ɥ</sub> -i	.i.mi.tai.	.i- <u>mi.ta-i</u> .

The difference between these two cases can be found at the prosody/morphology interface, as shown by the column labeled *Joint Analysis* in (53). The form *\*itai* is evidently a kind of extreme portmanteau morph, in which the entire root and suffix are contained within a single syllable *.ta-i*. In *imitai*, though, the fusion of morphologically distinct entities is incomplete, since part of the root (*mi*) remains in a syllable separate from the one containing the suffix.

Compare (53) with the contrast underlying the **Suffix Size** observation (ii). This is the contrast between *itau<sub>ɥ</sub>iro* from /i-tau<sub>ɥ</sub>-i-ro/ and *itaakiro* from /i-tau<sub>ɥ</sub>-ak-i-ro/:

(54) *itau<sub>ɥ</sub>iro/itaakiro* Contrast

	<i>Morphological Analysis</i>	<i>Prosodic Analysis</i>	<i>Joint Analysis</i>
a.	i- tau <sub>ɥ</sub> -i-~	.i.ta.ɥi.~ *i.tai.~	.i-.ta.ɥ-i.-~ *i- <u>ta-i</u> .~
b.	i-tau <sub>ɥ</sub> -ak-i-~	.i.taa.ki.~	.i- <u>ta-a</u> .k-i. ~

In (54b), the syllable *.ta-a.*, though it wholly contains the root, does not wholly contain the suffix *-ak*. But in *\*itairo*, absence of the velar glide creates the portmanteau syllable *.ta-i.*, which contains the entire root and suffix.

Descriptively, the velar glide remains when the root is short and the suffix is short because the glide-less candidate has a single syllable containing the whole root and suffix. Functionally, one might speculate that root and suffix would be excessively obscured if both were squeezed into one syllable. The constraint itself refers to the “Joint Analysis” of a form — that is, it is a constraint on the prosody/morphology interface, like ALIGN or SFX-TO-PRWD. One formulation of this constraint is the following:

## (55) RT-SFX-SEGREGATION

A root and a suffix cannot be wholly contained in a single syllable.

Stated as an edge constraint, in terms of the notation used in (53, 54), RT-SFX-SEGREGATION prohibits the configuration  $*.X\alpha-\beta Y.$ , where  $\alpha$ =Root,  $\beta$ =Suffix, and  $X\alpha\beta Y \neq \text{“.”}$ .

RT-SFX-SEGREGATION must dominate  $a$ =VOWEL, since otherwise it would be without force and could not prohibit velar glide loss in (52). This is a typical instance of Pāṇini’s Theorem, evoked by the fact that  $a$ =VOWEL applies to every occurrence of the velar glide. The following ranking example certifies this result:

(56) RT-SFX-SEGREGATION  $\gg$   $a$ =VOWEL, from /i-tau-i/

Candidates	RT-SFX-SEGREGATION	$a$ =VOWEL
 .i-ta.u-i.		*
i-ta-i.	* !	

On the other hand, RT-SFX-SEGREGATION must be dominated by FILL. This can be seen from a velar glide loss example (57) and from the combination of a monoconsonantal root like /p/ ‘feed’ with one of the -V suffixes -i ‘future’ or -a ‘perfect’ (58).

(57) FILL  $\gg$  RT-SFX-SEGREGATION, from /i-tau-i/

Candidates	FILL	RT-SFX-SEGREGATION
 .i-ta.u-i.		*
i-ta-.Ti.	* !	

(58) FILL  $\gg$  RT-SFX-SEGREGATION, from /pi-N-p-i-ri/ ‘you-FUT-feed-FUT-him’

Candidates	FILL	RT-SFX-SEGREGATION
 pim-p-i-ri		*
pim-pA-.Ti-ri	* !	

In the latter case,  $*pim-pAT-i-ri$  obeys RT-SFX-SEGREGATION at the expense of violating FILL. Thus, RT-SFX-SEGREGATION, unlike SFX-TO-PRWD, cannot lead to augmentation.

This analysis explains all of the observations about velar glide loss and retention laid out above. It permits loss of the velar glide when the root is long (/i-mitau-i/  $\rightarrow$  *imitai*) or when the suffix spans more than a single syllable (/i-tau-ak-i-ro/  $\rightarrow$  *itaakiro*), accounting for the **Root Size** (i) and **Suffix Size** (ii) observations. It also accounts, without additional stipulations, for the other two observations about the distribution of the velar glide. **Suffix Status of V** (iii)

asserts that the vowel following a retained velar glide must be suffixal, not epenthetic. Since epenthetic vowels have no morphological status as suffixes, roots, or anything else, RT-SFX-SEGREGATION says nothing about the fusion of a short root with an epenthetic vowel, as in *aa* from /auɰA/. (Of course, the spelling-out of epenthetic segments as *a* and *t* at the level interface (§3) does not change the fact that they have no morphological affiliations.) Finally, **Root Status of ɰ** (iv) says that the retained velar glide must itself be part of a root rather than part of a suffix. Since RT-SFX-SEGREGATION specifically refers only to root+suffix sequences, it will not affect velar glide loss in suffix+suffix contexts, so loss of suffixal /ɰ/ is unproblematic.

The Word-level constraint RT-SFX-SEGREGATION is sensitive, of course, to the prefix/root/suffix distinction inherited from earlier levels of the grammar. This is fully consistent with the position we have taken throughout (§3, §5.3), paralleling the fact that the Suffix-level constraint  $R \leq \text{ROOT}$  must be sensitive to the prefix/root distinction. As we have noted, even in the literature on Bracket Erasure, it is accepted that the identity of morphemes remains fully accessible at later levels of the phonology and morphology (Kiparsky 1982, Inkelas 1989).

One fact in (52) remains unaccounted for: why is velar glide loss blocked with the disyllabic root /irauɰ/? This root is apparently a ἄπαξ λεγόμενον of the /VCauɰ/ type, so it is crucial evidence for Black's (1991a) and Spring's (1991) claim that initial onsetless syllables are extrametrical. We have consistently maintained that initial onsetless syllables are *intrametrical*, presenting arguments in support of our position in §6. Thus, we must find another explanation for the patterning of /irauɰ/ with the monosyllabic roots /auɰ/, /tauɰ/, and /mauɰ/ rather than with disyllabic roots like /mitauɰ/.

As it happens, there is real doubt that this root is /irauɰ/ and good reason to think that its true underlying form is /rauɰ/, with prothetic *i* added for phonological reasons. Payne (1981:72) notes that *r* is infrequent word-initially, and an examination of Payne's root lexicon, containing approximately 850 entries, yields only a single *r*-initial root, the loan *rapisi* 'pencil' (Spanish *lapiz*). On the other hand, roots with initial *ir* are surprisingly common: of 60 *i*-initial roots, 11 begin with *ir* like /irauɰ/. (As a control, consider the fact that, of 90 *a*-initial roots, only 2 begin with *ar*, and of 68 *o*-initial roots, none at all begin with *or*.) To put this differently, in the root lexicon as analyzed by Payne (1981) and assumed by subsequent analysts, *r*-initial roots are unknown and *ir*-initial roots are disproportionately common. This oddly skewed distribution only makes sense if the putative *ir*-initial roots are actually *r*-initial, with prothetic *i* added in obedience to a prohibition on initial *r*. Of course, there may be *some* authentic *ir*-initial roots (presumably /ir/ 'drink' is one), but clearly many apparent *ir*-initial roots are actually *r*-initial. If /irauɰ/ is really /rauɰ/, then it will be correctly subject to RT-SFX-SEGREGATION like any other monosyllabic root.<sup>122</sup>

Summing up, we have established the following ranking relations in this section:

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<sup>122</sup>Further evidence for *i* prothesis before initial *r* comes from the free variation observed in the surface form of the 3rd masculine singular SPEC prefix (Payne 1981:83): *iranani* ~ *ranani* ~ *hanani* 'his black dye' (root /ana/), *irooki* ~ *rooki* ~ *hooki* 'he will abandon' (root /ook/). The analysis of these *i*/Ø alternations is not completely clear, but they are consistent with our proposal.

## (59) New Rankings

Ranking	Effect
FILL $\gg$ $a$ =VOWEL	Velar glide retained rather than C-epenthesis in unsyllabifiable sequences (46).
$a$ =VOWEL $\gg$ NONFINALITY	Velar glide loss can lead to final stress (48).
RT-SFX-SEGREGATION $\gg$ $a$ =VOWEL	Velar glide retained with short root and /V/ suffix (56).
FILL $\gg$ RT-SFX-SEGREGATION	Velar glide retained rather than C-epenthesis with short root and /V/ suffix (57); no augmentation to separate /C/ root from /V/ suffix (58).

This reduces to a strict ordering of the four constraints involved:

## (60) Word-level Hierarchy (Velar glide constraints)

FILL  
 $\gg$   
 RT-SFX-SEGREGATION  
 $\gg$   
 $a$ =VOWEL  
 $\gg$   
 NONFINALITY

And this hierarchy can be combined with the results of §A.2 to obtain a complete Word-level constraint hierarchy:

## (61) Word-Level Constraint Hierarchy (Final)

ONSET, CODA-COND, etc.  
 FTBIN, PARSE-*seg*, etc.  
 WSP  
 $\gg$   
 FILL  
 $\gg$   
 RT-SFX-SEGREGATION  
 $\gg$   
 $a$ =VOWEL  
 $\gg$   
 NONFINALITY  
 $\gg$   
 PARSE-SYLL  
 $\gg$   
 FT-FORM, PARSE- $\mu$   
 ALIGN, SFX-TO-PRWD

This final form of the Word-level hierarchy is generally compatible with the conception of the Suffix-level hierarchy and of the relation between the two levels developed in §A.2. In particular, the ranking of RT-SFX-SEGREGATION below FILL, motivated in (58), ensures that FILL cannot be visibly active anywhere in the Suffix-level phonology.



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