Prosodic Morphology

Constraint Interaction and Satisfaction

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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 Kissock (1998), Hale, Kissock, 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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ROA = Rutgers Optimality Archive, http://roa.rutgers.edu.

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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 (μ), syllable (σ), 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 circumscriptional 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 circumscriptional 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 circumscriptional 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 circumscriptional nor templatic. Proposal (3b) generalizes templatic and circumscriptional 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 circumscriptional 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 circumscriptional 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*$_i$, *surface-form*$_k$). In much modern work, the overall pairing resolves into a chain of pairs (*input*$_i$, *output*$_j$) for each lexical level, where *output*$_j$ 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) A → B / C—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-α 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 (Liberman 1975, Liberman 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 ouput, 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) $\text{Gen}(\text{in}_i) \rightarrow \{\text{cand}_1, \text{cand}_2, \ldots.\}$
$\text{Eval}(\{\text{cand}_1, \text{cand}_2, \ldots.\}) = \text{out}_{real}$

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-α (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.[1] 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.[2]

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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[1]For a skeptical view of phonological constraints, see Bromberger and Halle (1989).

[2]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), Rosenthall (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 ≫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 ≫B, /in_k/

Candidates	A	B
☞ $cand_1$		*
$cand_2$	* !	

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 ☞ 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 ≫B, /in_j/

Candidates	A	B
$form_1$		* !
☞ $form_2$		

This represents the same hierarchy A ≫B, faced with another input in_j, which underlies a completely different candidate set {$form_1$,$form_2$}. 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 ≫B, /in_m/

Candidates	A	B
$candform_1$	*	* !
☞ $candform_2$	*	

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.[3]

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[3]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).[4] 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 cand_i fares better than cand_j, we will write $\text{cand}_i \succ \text{cand}_j$ for 'cand_i is more harmonic than 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.[5]

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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: **ɔɛ* and **wʊ*, both of which are completely true of the surface (Paradis 1988b:12). Raising *ɔ* to *ʊ* in /wɔ-ɛ/ 'I make PRO shout' repairs a violation of **ɔɛ*, but it creates a violation of **wʊ*, so **ɔɛ* and **wʊ* 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 **ɔɛ* takes precedence over **wʊ* in Gere /wɔ-ɛ/, because the violation of **ɔɛ* was created by a suffixation rule.

Although constraint conflicts will lead to violations at intermediate stages of the derivation (so Gere underlying /wɔ-ɛ/ becomes intermediate /wʊ-ɛ/, which violates **wʊ*), 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 /wʊ-ɛ/ becomes *gʊ-ɛ*, removing the violation of **wʊ*). (We are indebted to Robert Kirchner for discussions that clarified this aspect of TCRS.)

[4] 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.

[5] 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 $cand_1 \succ cand_2$, where $cand_1 \in \text{Gen}(in_i)$ and $cand_2 \in \text{Gen}(in_j)$ for distinct underlying forms in_i and in_j, but nonetheless $cand_1$ is **not** optimal although $cand_2$ is! In this case, we would have to say that $cand_1$ is 'more well-formed' than $cand_2$, although it is *ill*-formed and $cand_2$ 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.[6] To see this, suppose that the two forms F and G violate the some 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 $\{***\}_{\mathbb{C}}$ and G a violation-set $\{*\}_{\mathbb{C}}$ 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–*

Root	*um+Root*	
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'.

---

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

[6] 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/ → { *.***um***.su.lat. / .s***u***.***m***u.lat. }

(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.[7] 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 ≫ EDGEMOST(L, *um*) on the grammar of Tagalog. The function Gen will produce, for every affix, every possible placement in and around the Base.[8]

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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[7]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 $w \subset y$.

[8]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
.***UM***.su.lat.	** !	Ø
☞ .s***U.M***u.lat.	*	s
.su.***UM***.lat.	** !	su
.su.l***U.M***at.	*	sul !
.su.la.***UM***t.[9]	*	sula !
.su.la.t***UM***.	*	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.[10]

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
☞ *U.M*a.ral.	*	Ø
.a.*UM*.ral.	** !	a
.a.r*U.M*al.	*	ar !
.a.ra.*UM*l.	*	ara !
.a.ra.l*UM*.	*	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

[9]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.

[10]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-intial words /um+gradwet/

Candidates	NOCODA	EDGEMOST
.*UM*.grad.wet.	*** !	Ø
.g*UM*.rad.wet.	*** !	g
☞ .gr*U.M*ad.wet.	**	gr
.grad.w*U.M*et.	**	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 ≫ 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.[11] 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 ≫NOCODA, the syllabic constraint will be rendered irrelevant

[11]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.[12] 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 σ dominates μ 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.[13]

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).[14] 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

---

[12]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.

[13]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).

[14]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 appropiate node in the prosodic tree, 'parsed'. Parse-*seg* demands that the segments belong to syllabic or moraic structure; Parse-μ demands that a mora μ is dominated by σ, the syllable node; Parse-σ 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.[15] 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.[16] 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□.□□.

---

[15]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.

[16]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 trisyllable, 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-observing [.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 ≫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.[17] 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/:

[17]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.[18]

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,

[18]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 fundmental 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), Rosenthall (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 invevitable 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.[19]

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 Categorial Phonology (Wheeler 1981, Bach and Wheeler 1981) and Declarative Phonology (Scobbie 1992).) As usual, it is interesting and useful to conceive of

[19] *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:[20]

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

(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.[21] (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).

[20]Different assumptions than these, especially 1. and 2., are explored at length by Rosenthall (in prep.) and Sherer (in prep.).

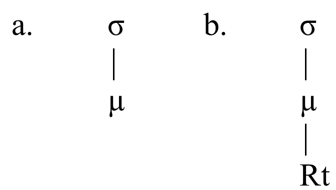
[21]The proposal that unsyllabified segments persist, made for Bella Coola (Bagemihl 1991) and Spokane Salish (Bates and Carlson 1992), is obviously problematic in this regard.

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:

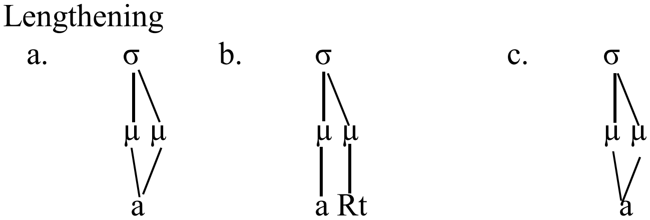
(24) Vocalic Epenthesis (Rt = feature-geometric root-node)



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.[22]

(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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[22]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 $[Rt\ \ldots]_{\sigma}$. 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

Prefix Level	⇒	Suffix Level	⇒	Word Level

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).[23] The constraint hierarchies at each level will overlap only in part, and will in fact specify somewhat different constraint rankings. Each

[23]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 ≫ 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 ≫ 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

Stem	*Suffixed form*	
a. /na/	na𝕋𝔸–piro–~	'truly carry on shoulder ...'
b. /no-na/	no-na–piro–~	'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

Root	*Stem*	*Stem+RED*	
a. /naa/	/no-naa/	no-naa–nonaa–~	'I chew more and more ...'
b. /asi/	/n-asi/	n-asi–nasi–~	'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

Root	*Complex Form*	*Reduplication*
/piiŋka/	/no-*o*-piiŋka-RED/ '1st+caus.+submerge+redup.'	no-***w***iiŋka–***w***iiŋka

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.[24] 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.[25] 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.

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[24]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-wiiŋkaanc^{h}i* 'to dunk' from /piiŋk/), but not in inalienably possessed nouns (*no-pori* 'my thigh') or non-causative verbs (*no-piiŋkaki* 'I will dunk').

[25]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:[26]

•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:

[26]See Zec (1992) for a discussion of such constraints within Optimality Theory.

(2) Fate of C+C

/no-N-*čʰik*⌣wai–i/	noñčʰi<u>k𝔸w</u>ai𝕋i	‘I will continue to cut’
/no-N-*tasoŋk*⌣wai–i/	nontasoŋ<u>k𝔸w</u>ai𝕋i	‘I will continue to fan’
/no-N-*aacik*⌣wai–i/	naaci<u>k𝔸w</u>ai𝕋i	‘I will continue to stop’

The *k+w* clusters in the underlying representations cannot be faithfully syllabified without violating CODA-COND. Forms with epenthetic 𝔸 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 𝔸. 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-čʰik–wai/

Candidates	CODA-COND	FILL
~.čʰik.wai.	*!	
☞ ~.čʰi.k𝔸.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^{h}ik–wai/

Candidates	PARSE	FILL
☞ ~.č^{h}i.k𝔸.wai.		*
~.č^{h}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 been seen in the following tableau, which gathers together the comparisons just examined:

(5) /no-N-č^{h}ik–wai/, Full Treatment

Candidates	PARSE	CODA-COND	FILL
☞ ~.č^{h}i.k𝔸.wai.			*
~.č^{h}ik.wai.		* !	
~.č^{h}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. *iŋkimpiro𝕋i
b. iŋkim𝔸piro𝕋i

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 ≫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

$*[_\sigma V$

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 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 ⌣.

(9) 𝕋-Epenthetic Examples

/i-N-koma⌣i/	iŋkoma𝕋i	'he will paddle'
/i-N-koma⌣aa⌣i/	iŋkoma𝕋aa𝕋i	'he will paddle again'
/i-N-koma⌣ako⌣i/	iŋkoma𝕋ako𝕋i	'he will paddle for'
/i-N-koma⌣ako⌣aa⌣i–ro/	iŋkoma𝕋ako𝕋aa𝕋iro	'he will paddle for it again'
/i-N-č^{h}ik–i/	iñč^{h}iki	'he will cut'
/i-N-č^{h}ik–aa⌣i/	iñč^{h}ikaa𝕋i	'he will cut again'
/i-N-č^{h}ik–ako⌣i/	iñč^{h}ikako𝕋i	'he will cut for'
/i-N-č^{h}ik-ako⌣aa⌣i–ro/	iñč^{h}ikako𝕋aa𝕋iro	'he will cut for it again'

The appearance of 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 ≫FILL, from /iN-koma-i/

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

The candidate-comparison here shows that FILL conflicts with ONSET. Since performance on ONSET is decisive, we conclude that ONSET ≫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 *.iŋ.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 **iŋ.ko.**mai***. Given the constraints we have in hand, this is superior to FILL-violating *iŋ.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. $[_{PrWd}$—

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.[27] 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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[27]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 ≫ONSET.[28] The effects on initial C-epenthesis are shown in (16), where the symbol | marks the relevant morphological edge (here, $[_{\text{Stem}}$) and the bracket [marks the relevant prosodic edge (here, $[_{\text{PrWd}}$).

(16) Failure of Prothesis, from /oti–aanc^{h}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 phonologicall-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^{h}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.

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[28]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 ≫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.[29] 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 *intra*metrical, 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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[29]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^h]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 **.iŋ.ko.mai.* violates no phonological constraints at all and is superior, in terms of pure phonology, to the actual epenthetic output *.iŋ.ko.ma.𝕋i.*, which violates FILL.[30] 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/	.iŋ.ko.ma|.𝕋i.
	*.iŋ.ko.ma|i.
b. /iN-koma⌣ako⌣i/	.iŋ.ko.ma|.𝕋a.ko|.𝕋i.
	*iŋ.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.[31] This constraint was first introduced in Prince and Smolensky's (1991b, 1993) analysis of Lardil.[32]

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[30]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.

[31]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):

$$Ø \rightarrow t \,/\, V]_{Verb} + \_\_\_\_ \; V$$
$$Ø \rightarrow a \,/\, C]_{Verb} + \_\_\_\_ \; C$$

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.)

[32]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

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

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), Align(Stem, Right, Syllable, 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|𝔸.	'fish'
b. /maṛ/	.maṛ|.𝕋̣𝔸, *.ma.ṛ|𝔸.	'hand'

Lardil syllables don't end on *k*, forcing misalignment of */yak/* in (20a). The root */maṛ/* in (20b), by contrast, is susceptible to syllabification in its entirety. As a consequence, augmentation is driven beyond the absolute minimum: we find 𝕋̣𝔸 where 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 𝕋̣𝔸 where 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:

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 MCAT=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 ≫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 ≫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 ≫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 ≫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⁀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~/ .iŋ.*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.[33]

(25) CODA-COND ≫ALIGN, from /no-N-č^{h}ik-wai/

Candidates	CODA-COND	ALIGN
☞ ~.*č^{h}i.k*|𝔸.wai.		*
~.*č^{h}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 C𝔸C 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^{h}ik-wai/

Candidates	PARSE	CODA-COND	ALIGN	FILL
☞ ~.č^{h}ik𝔸wai			*	*
~.č^{h}ik|.wai.		*!		
~.č^{h}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.

[33]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^{h}ik+aanc^{h}i/ 'to cut (infinitive)'

Candidates	ONSET	CODA-COND	ALIGN	FILL
a. ☞ .*č^{h}i*.*k*|aan.c^{h}i.			*	
b. .*č^{h}ik*|.aan.c^{h}i.	*!	*!		
c. .*č^{h}ik*|.𝕋aan.c^{h}i.		*!		*
d. .*č^{h}i*.*k*|𝔸.aan.c^{h}i.	*!		*	*
e. .*č^{h}i*.*k*|𝔸.𝕋aan.c^{h}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^{h}i* (for actual *ki.m*|*aan.c^{h}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^{h}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*^{h}*i*, With Linking

*kim.ℙaan.c^{h}i
\/
Place
|
[labial]

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*^{h}*i*, Without Linking

*kim.ℙaan.c^{h}i
|
Place
|
[labial]

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 *iŋkoma𝕋i*, the cyclic domain *.iŋ.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.[34]

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 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 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 ≫FILL	Epenthesis to provide onset (10)
ALIGN ≫FILL	Epenthesis, not coalescence, at V+V juncture, *.Ca|i. (21)
CODA-COND ≫ALIGN	Syllable well-formedness not sacrificed to get alignment (25)
ALIGN-L ≫ONSET	No epenthesis in Stem-initial position[35] (16)

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

[34]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 ≫PARSE (16) or NOCODA ≫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.	*!		*	

[35]See fn. 28 for discussion of the possibility of non-ranking of these constraints.

(31) Crucial Ranking Sequences[36]

a. PARSE, ONSET ≫FILL

b. CODA-COND ≫ALIGN ≫FILL

c. ALIGN-L ≫ONSET

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

(32) Conflated Hierarchy

PARSE, CODA-COND, ALIGN-L ≫ONSET, ALIGN ≫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

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

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 V$\mathbb{T}$V 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.

[36]PARSE ≫FILL is justified in (4) §4.1. CODA-COND ≫FILL follows from transitivity of ≫, but is justified directly in (3) §4.1.

The explanation for the legitmacy 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

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

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 a 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

PrWd
|
Ft
|
σ
|
μ

The units of prosody are the mora μ, the syllable σ, 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 moraically. 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	σσ
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) or degenerate feet (Prince 1980, McCarthy and Prince 1991a):

(37) Foot Binarity (FtBin)

Feet must be binary under syllabic or moraic analysis.

The Prosodic Hierarchy and Foot Binarity, 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 Binarity, 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			
/wit̪e/	wit̪e	wit̪e-n	‘inside’
/peer/	peer	peer-in	‘ti-tree sp.’
b. Monomoraic Base			
/wik/	wik𝔸	wik-in	‘shade’
/ƭer/	ƭer𝔸	ƭer-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 *wit̪e*, 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	wila-wila	‘woman’
ŋankanti	ŋanka-ŋankanti	‘catfish’
tʲilparku	tʲilpa-tʲilparku	‘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 **tʲilpar-tʲilparku*, 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.	mula-mulari	‘initiated man’
.t^{j}u.kar.pa.	t^{j}ukar-t^{j}ukarpa-n	‘unsettled mind’
.kin.tal.pa.	kintal-kintalpa	‘lizard species’
.ka.la.^{m}pa.ɽa.	kala-kala^{m}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^{h}i* ‘infinitive’, *-piro* ‘verity’, and *-RED* ‘more and more’:[37]

(41) The Augmentation System

Root		__+V…	__+C…	__+RED
/na/	*Aug.*		na$\mathbb{TA}$–piro$\mathbb{T}$aanc^{h}i	na$\mathbb{TA}$–na$\mathbb{TA}$–wai$\mathbb{T}$aki
	Nonaug.	na–$\mathbb{T}$–aanc^{h}i	no-na–piro$\mathbb{T}$i	no-na–nona–wai$\mathbb{T}$i
/p/	*Aug.*		p$\mathbb{AA}$–piro$\mathbb{T}$aanc^{h}i	p$\mathbb{AA}$–p$\mathbb{AA}$–wai$\mathbb{T}$aki[38]
	Nonaug.	p–aanc^{h}i		no-w$\mathbb{A}$–now$\mathbb{A}$–wai$\mathbb{T}$i

[37]The alternations exemplified by /na/ are typical of monomoraic roots like /to/ ‘cut the hair’, /t^{h}o/ ‘kiss, suck’, and /si/ ‘defecate’. The alternations exemplified by /p/ are typical of monoconsonantal roots like /č/ ‘enter’, /ñ/ ‘see’, and /ñ/ ‘talk’. The example *p$\mathbb{AA}$-piro$\mathbb{T}$aanc^{h}i* is not directly attested in our sources, but was constructed on the basis of the equivalent form *ñ$\mathbb{AA}$-piro$\mathbb{T}$aanc^{h}i* from the root /ñ/ (Spring 1990c:149). The example *om-p$\mathbb{A}$-wai$\mathbb{T}$iroota* ‘she might continually feed to her/it’ (Payne 1981:242) confirms that monoconsonantal roots like /p/ do not augment when prefixed.

[38]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

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

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:

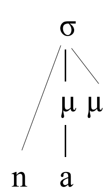
(44) Augmentation of /na/

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

Note that the crucial domination relation ALIGN ≫FILL is already established. Since Axininca Campa has both underlying and derived long vowels,[39] 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 $/n[a]_\mu/$. 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 $[a]_\mu$ is not in syllable-final position: the branch of the σ-tree dominating material from the morpheme does not coincide with the rightmost branch of σ. 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|.

[39]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

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

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
☞ .|p|AA.				*	**
.|p|A.TA.				*	*** !
.|p|A.A.			* !	*	**
[.A|p|.	* !	* !	*		*
[.TA|p|.	* !	* !			**
[.A.|p|A.		* !	*	*	**
[.TA.|p|A.		* !		*	***

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*.[40]

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^ho/, so that the contrast is phonetically apparent:

[40] 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^ho.|𝕋𝔸. ☞ t^ho𝕋𝔸
b. [t^h𝔸.𝕋o.| * t^h𝔸𝕋o

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.[41]

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 Binarity (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^{h}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.)

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[41] Alternatively, **t^h𝔸𝕋o* (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^ho𝕋𝔸* (51a) over **t^h𝔸𝕋o* (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.[42] Equivalently, it is one in which the initial element of the suffix abuts the final element of a PrWd.[43]

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 augmentaton 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			**

---

[42]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.

[43]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.ji̱s* 'save', *ar.ji̱s* 'plow' vs. *soo.ki̱is* 'seek', *nam.ni̱is* 'name', *miki.li̱is* 'glorify', *glit.mu.ni̱is* '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 *na𝕋𝔸] |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^{h}i/. The direct assault, simply paralleling the augmentation style before the C-initial suffixes, runs afoul of ONSET:

(56) *na𝕋𝔸].|aan.c^{h}i

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) *na𝕋𝔸].𝕋|aan.c^{h}i

Ill-aligned *na𝕋𝔸]𝕋|aanc^{h}i* must then face ill-aligned *na𝕋|aanc^{h}i*]. 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: *na𝕋aanči*, 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^{h}i/

Candidates		ONSET	FTBIN	SFX-TO-PRWD	FILL
a.	na].|aanc^{h}i	*!	*!		
b.	na𝕋𝔸].|aanc^{h}i	*!			**
c.	na.|aanc^{h}i]	*!		*	
d.	na𝕋𝔸].𝕋|aanc^{h}i			*	***!
e.	☞ na.𝕋|aanc^{h}i]			*	*

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^{h}ik–aanc^{h}i/, 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…]$_\sigma$

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^{h}ik/. Only syllabically well-formed candidates are shown.

(62) /$\check{c}^h$ik+aanc^{h}i/ 'to cut (infinitive)'

Candidates	ALIGN	SFX-TO-PRWD	FILL
☞ .$\check{c}^h$i.k||aan.c^{h}i.]	*	*	
.$\check{c}^h$i.k|𝔸.]𝕋|aan.c^{h}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^{h}i/ would trigger augmentation to *na𝕋𝔸.aanc^{h}i*. But this form violates ONSET, so it would be subject to further repair, yielding **na𝕋𝔸𝕋aanc^{h}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 $cand_1$ and $cand_2$ is optimal:

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

Candidates	ALIGN	SFX-TO-PRWD
$cand_1$	*	
$cand_2$		*

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 $cand_2$. Only suffixes C… can yield suffix-aligned forms like $cand_1$. 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/ na𝕋𝔸–na𝕋𝔸–wai𝕋aki
b. /p–RED–wai–ak–i/ p𝔸𝔸–p𝔸𝔸–wai𝕋aki
c. /p–RED–ak–i–na/ p𝔸𝔸–p𝔸𝔸–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.[44] 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

[44]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 ≫SFX-TO-PRWD, because suffixal alignment cannot be achieved at the expense of syllabic wellformedness (*V|.V).

•SFX-TO-PRWD ≫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:

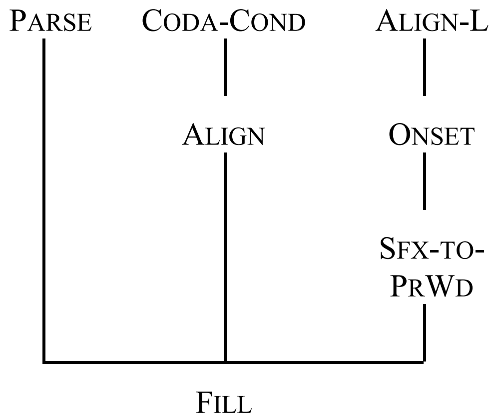
(67) New Rankings

Rankings	Effects
PARSE ≫FILL	Epenthesis rather than deletion (4)
ONSET ≫FILL	Epenthesis to provide onset (10)
CODA-COND ≫FILL	Epenthesis to provide nucleus (3)
ALIGN-L ≫ONSET	No epenthesis in stem-initial position[45] (16), (48) Onsetless initial syllables freely allowed
CODA-COND ≫ALIGN	Coda well-formedness not sacrificed to get stem-alignment (25)
ALIGN ≫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 ≫SFX-TO-PRWD	Onset well-formedness not sacrificed to get suffix-alignment (56)
SFX-TO-PRWD ≫FILL	Augment to gain well-formed PrWd (54)

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

[45] See fn. 28 for discussion of the possibility of non-ranking of these constraints.

(68) Linguistically-significant Constraint Rankings



Because the motivated rankings provide a properly partial order on the constraint set, they can be flattened out in a number of equivalent ways. Here is one:

(69) Parse, Coda-Cond, Align-L ≫Onset ≫Align, Sfx-to-PrWd ≫Fill

Given that Sfx-to-PrWd and Align are formally similar and are unranked with respect to each other in the constraint hierarchy, as can be seen in diagram (68), it is reasonable to ask whether one could do the work of both or whether they could be conflated. This seems very unlikely. Align deals with stem-internal matters, and asks only for a syllable-edge; Sfx-to-PrWd looks at both Base and suffix, and wants a full PrWd. Because of this, their domains of relevance are quite different. On the one hand, Sfx-to-PrWd fails to make distinctions that Align makes. Sfx-to-PrWd is violated by both of the two nondeleting treatments of heteromorphemic vowel sequences, epenthesis of 𝕋 and coalescence into a single syllable; but these are crucially distinguished by Align. Similarly, Sfx-to-PrWd is *satisfied* by both moraic and syllabic augmentation of forms like /na/, leading to either *na𝕋𝔸* or **na𝔸*, but only the syllabic pattern obeys Align. On the other hand, Align fails to make distinctions that Sfx-to-PrWd does, since it says nothing about the necessity of augmentation. Sfx-to-PrWd is required to force forms like *na𝕋𝔸piro*, since **napiro* obeys Align perfectly well.

It is a fundamental thesis of Optimality Theory that Universal Grammar consists largely of a body of general constraints which when ranked provide the grammars of individual languages. If this view is to have any hope of success, then the interaction effects due to ranking must be able to wring very particularized consequences from the very general constraints of UG. The prosody-morphology alignment system examined in this section shows exactly this desired property.

Align-L demands coincidence of the initial edge of the PrWd and the initial edge of the stem. Although free of mention of syllables or segments, it allows us to limit UG to a single general exception-free formulation of Onset. In addition, it provides essential support to the conception of epenthesis that is based on completely free generation of empty structure: neither Gen nor Fill need be encumbered with any mention of intial or final position. The dominance relations between these constraints entail not only that syllabic and moraic augmentation is noninitial, but also that onsetless initial syllables will be freely tolerated in the language.

Align demands that the right edge of the stem coincide with the right edge of a syllable, aiming for another kind of prosodic closure. This bans coalescence of heteromorphemic V+V 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: ≥ σσ.

Total Reduplication of Root, excluding Prefix.

kawosi–kawosi	*noŋ*-kawosi–kawosi	'bathe'[46]	
t^{h}aaŋki–t^{h}aaŋki	*non*-t^{h}aaŋki–t^{h}aaŋki	'hurry'	
kint^{h}a–kint^{h}a	*noŋ*-kint^{h}a–kint^{h}a	'tell'	
č^{h}ika–č^{h}ika	*noñ*-č^{h}ika–č^{h}ika	'cut'	/č^{h}ik/
tasoŋka–tasoŋka	*non*-tasoŋka–tasoŋka	'fan'	/tasoŋk/

b. C-initial Short roots: ≤ σ.

Total Reduplication of Stem, including Prefix.

(i)	naa–naa	*no*-naa–*no*naa	'chew'	
(ii)	nata–nata	*no*-na–*no*na	'carry'	/na/
	t^{h}ota–t^{h}ota	*non*-t^{h}o–*non*t^{h}o	'kiss, suck'	/t^{h}o/
	paa–paa	*no*-wa–*no*wa	'feed'	/p/

c. V-initial Long Roots: ≥ σσσ.

Reduplication excludes first syllable.

osaŋkina–saŋkina	*n*-osaŋkina–saŋkina	'write'	
osampi–sampi	*n*-osampi–sampi	'ask'	
oiriŋka–riŋka	*n*-oiriŋka–riŋka	'lower'	/oiriŋk/
aacika–cika	*n*-aacika–cika	'stop'	/aacik/
amina–mina	*n*-amina–mina	'look'	/amin/

d. V-initial Short roots: ≤ σσ.

Total Reduplication of Stem, including first syllable.

asi‖asi	*n*-asi–*n*asi	'cover'	
api‖apii	*n*-apii–*n*apii	'repeat'	/apii/
ooka‖ooka	*n*-ooka–*n*ooka	'abandon'	/ook/
aka‖aka	*n*-aka–*n*aka	'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

[46] 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. o*sampi*] _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 *apí*~) 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 ≥ σσ, the *Root* reduplicates but the prefix does not. (1a).

•For C-initial roots ≤ σ, 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 ≥ σσσ 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 ≤ σσ 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 unprefixed 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: Unprefixed 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:[47]

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

Base	*Reduplication*	*Gloss*
/kawosi/	kawosi–kawosi–wai𝕋aka	‘bathe’
/koma/	koma–koma–wai𝕋aki	‘paddle’
/kint^{h}a/	kint^{h}a–kint^{h}a–wai𝕋aki	‘tell’
/t^{h}aaŋki/	t^{h}aaŋki–t^{h}aaŋki–wai𝕋aki	‘hurry’
/naa/	naa–naa–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

[47]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*–<u>*naTA*</u> 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 $[\text{Base}]_{\text{PrWd}}$|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. $r_i \frown r_j \Rightarrow f(r_i) \frown f(r_j)$

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→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[48] (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.[49]

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[48]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.

[49]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.[50] 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^h*aaŋki*–t^h*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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[50]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 unprefixed 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^{h}ik/	č^{h}ik𝔸–č^{h}ik𝔸–wai𝕋aki	'cut'
/kow/	kow𝔸–kow𝔸–wai𝕋aki	'search'
/tasoŋk/	tasoŋk𝔸–tasoŋk𝔸–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 *kow𝔸–kow𝔸–* 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^{h}ik/	*č^{h}i.k–i.k~
/kow/	*ko.w–o.w~
/tasoŋk/	*ta.soŋ.k–a.soŋ.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.[51] 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.soŋ.k-a.soŋ.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

[51]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.[52] 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–~/

<table>
<tr><th>Candidates</th><th>Sfx-to-PrWd</th><th>Fill</th><th>Max</th></tr>
<tr><td>tasoŋ].k|a.soŋk~</td><td>*!</td><td></td><td>t</td></tr>
<tr><td>☞ tasoŋ.kA.]|tasoŋkA~</td><td></td><td>**</td><td></td></tr>
</table>

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:

[52] 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) /tasoŋk–RED–wai-ak-i/ Schematically

Base *Reduplicant*

tasoŋk 𝔸 $]_{PrWd}$ |tasoŋk𝔸 wai 𝕋 ak i

Root *RED* *CONT* *TNS* *AGR*

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

(13) /tasoŋk–RED–wai-ak-i/

Base *Reduplicant*

tasoŋ$]_{PrWd}$.k |a.soŋk 𝔸 wai 𝕋 ak i

Root *RED* *CONT* *TNS* *AGR*

Here the Base of reduplication, *tasoŋk*, 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 *tasoŋk𝔸–tasoŋk𝔸* 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 /tasoŋk–RED~/

Candidates	ALIGN	FILL	MAX
a. tasoŋ.k–a.soŋ.k|~	* !		t
b. tasoŋk𝔸–.ta.soŋ.k|~	* !		
c. ☞ tasoŋk𝔸–.ta.soŋ.k𝔸.|~		**	

The non-epenthetic Reduplicant *a.soŋ.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.soŋ.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 *tasoŋk𝔸* 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[53]

/no-č^{h}ik–RED–*akiri*/	-č^{h}ik𝔸 č^{h}ik𝔸–𝕋*akiri*	'I cut it and cut it' Spring (1990a: 109)
	*-č^{h}ik𝔸 č^{h}i.k–*a.kiri*	
/noŋ-kow–RED–*iro*/	-kow𝔸 kow𝔸–𝕋*iro*	'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 *kow*𝔸). 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).[54] 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

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[53]For morphological reasons, these examples have prefixes, whose reduplicative behavior will be taken up in §5.3 below.

[54]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: *iŋkoma*–𝕋*i*, **iŋkoma*–*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-inital syllables begin with consonants.[55]

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–sampi–wai𝕋aki	'ask'
/osaŋkina/	osaŋkina–saŋkina–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–sampi	*	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:

[55]We are indebted to Suzanne Urbanczyk for raising a question about this material that led to a major improvement in the analysis.

(18) /osampi–RED/

Candidates	ONSET	FILL	MAX
a. ☞ .o.sampi–<u>sampi</u>	*		o
b. .o.sampi.𝕋–<u>o.sampi</u>	*	*	𝕋
c. .o.sampi-<u>.𝕋o.sampi</u>	*	*	𝕋
d..o.sampi.𝕋–<u>o.sampi𝕋</u>	*	**	

Partial reduplication of roots /V~~V/, then, is a consequence of the low ranking afforded MAX in Axininca Campa.

With FILL ≫MAX, none of the epenthetic candidates in (18b-d) can be optimal, but this does not establish that FILL in particular is ultimately responsible for their demise. The losers here may also violate constraints ranked yet higher than FILL, and indeed this turns out to be true in every case. (For this reason, the eye-catcher !'s, which mark a crucially fatal confrontation, have been omitted from the tableau.)

C-epenthetic solutions like those in (18b-d) fall into two classes: asymmetric, like (18b,c), in which Reduplicant and Base are ill-matched; and symmetric, like (18d), in which Base and Reduplicant correspond perfectly. Accordingly, there are two different classes of explanations for the failure of these candidates.

Consider first the class of asymmetric forms. In **osampi𝕋–<u>osampi</u>* (18b), the epenthetic element is outside the Reduplicant; it is not morphologically affiliated with RED. It therefore serves as the last element of the Base. But this means that the suffixal Reduplicant doesn't correspond to the final substring of the Base, so the Reduplicant fails ANCHORING, a fatal violation. In the candidate analysis **osampi-<u>𝕋osampi</u>* (18c), the epenthetic C *is* assigned to the Reduplicant. In consequence, the Reduplicant is not a substring of the Base: a fatal violation of CONTIGUITY. Asymmetric epenthesis, then, is ruled out on very general grounds, since ANCHORING and CONTIGUITY are fundamental reduplicative constraints, typically undominated. This is a desirable result, because it is likely that such a pattern is not to be found in reduplicative systems.

The symmetric case (18d), with parallel epenthesis in Reduplicant and Base, has a different status. It is impeccable with respect to Base-Reduplicant matching. It resembles known cases of "overapplication" — the Axininca *na𝕋A–<u>na𝕋A</u>*~ type (29), with phonologically unmotivated augmentation in the Reduplicant, is a nearby example. There is little reason to believe that it is universally impossible. Language-specific constraint-ranking is therefore the appropriate means to rule it out. Though the pattern of FILL violation is sufficient to exclude this form, its worst violation is that of SFX-TO-PRWD, which dominates FILL. This effect is shown diagrammatically below:

(19) osampi].𝕋|<u>o.sampi𝕋</u>

The Base of reduplication *osampi𝕋* can never be optimally analyzed as a PrWd, since no Prosodic Word of Axininca Campa can be consonant-final, thanks to CODA-COND. In contrast, the reduplicative Base in *osampi–<u>sampi</u>* 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":[56] **𝕋osampi-<u>𝕋osampi</u>*. 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

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

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

(21) [𝕋|osampi-<u>𝕋osampi</u>

ALIGN-L is violated, fatally, by the first occurence of 𝕋 in forms like **𝕋osampi-<u>𝕋osampi</u>*.

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/	amin𝔸–<u>min𝔸</u>–wai𝕋aki	'look'
/oiriŋk/	oiriŋk𝔸–<u>riŋk𝔸</u>–wai𝕋aki	'lower'
/aacik/	aacik𝔸–<u>cik𝔸</u>–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)

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[56]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 *ʔalaʔ<u>al</u>* from /al/ 'summer' displays overapplication of *ʔ*-prothesis, since otherwise *ʔal<u>al</u>* 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–a.mi.n~
/oiriŋk/	*oi.riŋ.k–oi.riŋ.k~
/aacik/	*aa.ci.k–aa.ci.k~

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 *čʰi.kaan.cʰi* from /čʰik+aancʰi/.

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|oi.riŋ.k~	*vs.*	oi.riŋ.k𝔸.]|riŋ.k𝔸
/C——C/	/tasoŋk/	*ta.soŋ.]k|a.soŋ.k~	*vs.*	ta.soŋ.k𝔸.]|ta.soŋ.k𝔸

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–oi.riŋ.k|~	* !	* !		
☞ oiriŋ.k𝔸.]–riŋ.k𝔸.|~			**	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^{h}o/	t^{h}oTA–t^{h}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 unprefixed 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|na			* !	
b. na]|na	* !			
c. ☞ na|.TA]|naTA				****
d. na|A.]|naA		* !		**

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 $[na]_{PrWd}$ is too small. (28b).
- ☞ *[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
☞ naTA–naTA		****
naTA–na	* !	**

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 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
~na+RED+~ → *No Augmentation* → *~na na ~
b. Reduplication precedes Augmentation
~na+RED+~ → ~na na ~ → *~naTA na iro
c. Cyclic or Free Augmentation
~na+RED+~ → *No Augmentation* → ~na na ~ → *~naTA na ~

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 unprefixed 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≤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^{h}a/	noŋ-kint^{h}a–<u>kint^{h}a</u>–waiTi	'tell'
/non-t^{h}aaŋki/	non-t^{h}aaŋki–<u>t^{h}aaŋki</u>–waiTi	'hurry'
/non-tasoŋk/	non-tasoŋkA–<u>tasoŋkA</u>–waiTi	'fan'

Prefixes are carried along in reduplication under some conditions, as shown in forms like *no-naa–<u>nonaa</u>* (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≤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*.[57] R≤ROOT has an

[57]One might also contemplate demanding that the morphological category *root* be recognizeable within a Reduplicant, so that R≤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≤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.[58]

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 Pāṇini'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≤ROOT:

(33) /noŋ-kawosi–RED/

Candidates	R≤ROOT	MAX
noŋ-kawosi–noŋkawosi	* !	
☞ noŋ-kawosi–kawosi		noŋ

With MAX subordinate, R≤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≤ROOT is completely irrelevant, so that dominant MAX enforces total Base reduplication.[59]

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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≤ROOT.

[58]From R≤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≤ROOT is violated: **kawosi–wai–kawosiwai*. If the suffix is not copied, then undominated ANCHORING is violated: **kawosi–wai–kawosi*.

[59]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≤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–nokoma–waici	no-koma–koma–waici	'I continued to paddle more and more'
no-kiŋkit^{h}a–nokiŋkit^{h}a–waici	no-kiŋkit^{h}a–kiŋkit^{h}a–waici	'I continued to tell more and more'
n-osampi–nosampi–waiciri	n-osampi–sampi–waiciri	'I continued to ask her/it more & more'

Optional prefix reduplication shows that the ranking between MAX and R≤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≤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≤ROOT. Typical examples of a sort discussed in §5.2 are given here:

(34) *naTA–<u>naTA</u>~* **naTA–<u>na</u>~*
kowA–<u>kowA</u>–Tiro **kowA–<u>kow</u>~*

The explanation for this pattern lies in the relatively low ranking of R≤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≤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≤ROOT
a. ☞ noŋ-kowA–<u>kowA</u>–~		*
b. noŋ-kowA–<u>kow</u>–~	*!	
c. noŋ-kowA–<u>noŋkowA</u>–~		**!

This establishes that ANCHORING conflicts with and therefore crucially dominates R≤ROOT. Now, because of its position in the ranking, R≤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≤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≤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≤ROOT, and each such violation can be reckoned separately. In accordance with general principles of Optimality Theory, the minimal violation of R≤ROOT will be preferred. Thus, as shown, *noŋ-kowA–<u>kowA</u>–~*, which violates R≤ROOT in just one locus, is selected over (MAX-imizing) **noŋ-kow𝔸–noŋkow𝔸*, which violates it twice (at least, depending on how the violations are reckoned).[60]

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–sampi–wai𝕋i	'ask'
/n-osaŋkina/	n-osaŋkina–saŋkina–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≤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≤ROOT	MAX
n-osampi–nosampi		* !	
n-osampi–.osampi	* !		n
☞ n-osampi–sampi			no

This argument depends only on rankings already established, which place each of ONSET and R≤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≤ROOT. There is, however, one important phonological constraint on reduplication in Axininca Campa, evidenced by the behavior of short C-initial roots /C~/:

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

/no-w/[61]	no-w𝔸–now𝔸–wai𝕋i	'feed' (Spring 1990a:148-9; 1992)
/no-na/	no-na–nona–wai𝕋i	'carry'
/non-t^{h}o/	non-t^{h}o–nont^{h}o–wai𝕋i	'kiss, suck'
/no-naa/	no-naa–nonaa–wai𝕋i	'chew'

[60]The gradient interpretation of R≤ROOT is clearly a sensible one. Consider a hypothetical language like Axininca Campa but with multiple prefixes. Dominant DISYLL (v. infra) forces prefix reduplication with monosyllabic roots. If R≤ROOT were interpreted purely categorically, then all prefixes would be copied if one were, because MAX would be the determining constraint. But if R≤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.

[61]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*^{h}*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≤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^{h}o–t^{h}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≤ROOT in the hierarchy, to resolve the conflict in its own favor:

(41) /no-naa–RED/

Candidates	DISYLL	R≤ROOT	MAX
☞ no-naa–nonaa		*	
no-naa–naa	*!		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≤ROOT will apply to them with full force.

(42) /noŋ-kawosi-RED/

Candidates	DISYLL	R≤ROOT	MAX
☞ noŋ-kawosi-kawosi			noŋ
noŋ-kawosi–noŋkawosi		*!	

By virtue of dominating R≤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/ naTA] |wai~
b. /p/ pAA] |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
*naaTA-naaTA

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-naa		*
naaTA-naaTA	*!***	

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≤ROOT ≫MAX to complete the argument from transitivity of domination, putting together all the rankings just noted:

(46) Ranking Chain from FILL to MAX

FILL ≫DISYLL ≫R≤ROOT ≫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–<u>nona</u>*
b. LH *n-apii–<u>napii</u>*
c. HL *n-aasi–<u>naasi</u>*

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–<u>naa</u>* 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[62] 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. *Obeyed*	b. *Violated*
[no]$_\sigma$ [naa]$_\sigma$ [no]$_\sigma$ [naa]$_\sigma$	[no]$_\sigma$ [naa]$_\sigma$ [naa]$_\sigma$
Reduplicant	*Reduplicant*

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.[63] 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^{h}ik/	noñ-č^{h}ik𝔸–č^{h}ik𝔸–wai𝕋i	'cut'

b. /V~C/ Roots

/n-amin/	n-amin𝔸–min𝔸–wai𝕋i	'look'
/n-oiriŋk/	n-oiriŋk𝔸–riŋk𝔸–wai𝕋i	'lower'
/n-aacik/	n-aacik𝔸–cik𝔸–wai𝕋i	'stop'

---

[62]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.

[63]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^{h}ik𝔸–noñč^{h}ik(𝔸)
b. *n-amin𝔸–namin(𝔸)

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^{h}ik𝔸–č^{h}ik𝔸*

a. Epenthesis Precedes Reduplication
noñ-č^{h}ik+RED → *No Epenthesis* → *noñ-č^{h}ik–noñč^{h}ik

b. Reduplication Precedes Epenthesis
noñ-č^{h}ik+RED → noñ-č^{h}ik–noñč^{h}ik → *noñ-č^{h}ik𝔸–noñč^{h}ik(𝔸)

c. Cyclic or Freely-reapplying Epenthesis
noñ-č^{h}ik+RED → *No Epenthesis* → noñ-č^{h}ik–noñč^{h}ik → *noñ-č^{h}ik𝔸–noñč^{h}ik(𝔸)

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.[64]

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≤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

[64]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^{h}i.k*, 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≤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≤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 unprefixed, 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‖asi–wai𝕋aki	/n-asi/	n-asi–nasi–wai𝕋i	'cover'
/aasi/	aasi‖aasi–wai𝕋aki	/n-aasi/	n-aasi–naasi–wai𝕋i	'meet'
/apii/	api‖apii–wai𝕋aki	/n-apii/	n-apii–napii–wai𝕋i	'repeat'

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

(55) $[asi]_{PrWd}$ $[asiwaitaki]_{PrWd}$

According to Payne,[65] 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*]$_{PrWd}$ [*asíwáitaki*]$_{PrWd}$

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*]$_{PrWd}$ [*apiiwaitaki*]$_{PrWd}$

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) [*na**pii**napiiwaiti*]$_{PrWd}$
[*ko**wà**kowawáitaki*]$_{PrWd}$

(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.

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[65]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[66] constraint PRWD⊃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⊃ROOT

Each PrWd contains a root.

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

(60) /iŋkoma-ako-i/

a.*iŋkoma‖ako‖i
b. iŋkoma𝕋ako𝕋i

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

PRWD⊃ROOT further entails that the Prosodic Words [*asi*]$_{\text{PrWd}}$ and [*asiwai𝕋aki*]$_{\text{PrWd}}$ 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*]$_{\text{PrWd}}$ [*asiwaitaki*]$_{\text{PrWd}}$

([*asi*]$_{\text{Root}}$)$_{\text{Stem}}$ ([*asi*]$_{\text{Root}}$ –*wai*–*ak*–*i*)$_{\text{Stem}}$

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.

[66]Little is known about the sentence phonology of Axininca Campa, so it is impossible to say whether or not PRWD⊃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 ≫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.[67] The observation is that reduplicative compounding is not possible with forms like unprefixed /osampi/, as a way to copy the initial syllable:

(64) R=SFX ≫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.

[67]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≤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≤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; it 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. ☞apii‖apii–wai𝕋aki	* ‖ *
b. * 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. ☞apii‖<u>apii</u>–wai𝕋aki	* ‖ *
b. * apii‖<u>pii</u>-wai𝕋aki	* ‖

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,[68] so neither can have any effect here.

The explanation for the non-optimality of (67b) is quite simple. The Reduplicant *<u>pii</u>* is not a root of Axininca Campa, so *<u>pii</u>wai𝕋aki* violates undominated PRWD⊃ROOT (59). Suffixing reduplication may be incomplete, as indeed it is with long V-initial roots, as in *osampi–<u>sampi</u>* or *n-osampi–<u>sampi</u>* (§§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:

[68] 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–<u>sampi</u>* (§5.2).

(68) Without Prefix: /apii-RED/

Candidates	PRWD⊃ROOT	ALIGN-L	ONSET	DISYLL	R=SFX	MAX
apii–pii			*	*!		*
apii‖pii	*!		*‖	*	*	*
[𝕋|apii–𝕋apii		*!				
apii.apii			**!			
☞ apii‖apii			*‖*		*	

Remarks:

- *apii‖pii* violates undominated PRWD⊃ROOT, as explained above (67).
- *𝕋apii–𝕋apii* 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–𝕋apii* 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).
- ☞*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≤ROOT	MAX
n-apii–pii		*!			*
n-apii.apii	*!				*
n-apii‖apii	‖*!		*		*
☞ n-apii–napii				*	

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–waiČ̆aawoota ‘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, Ø → #) 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 ≫ R=SFX	apii‖apii ≻ *apii–pii	A compounded Reduplicant is chosen over a monosyllabic one.
R=SFX ≫ MAX	osampi–sampi ≻ *osampi‖osampi	Less-than-full reduplication material is chosen over a compounded Reduplicant.
R≤ROOT ≫ MAX	noŋ-kawosi–kawosi ≻ *noŋ-kawosi–noŋkawosi, n-osampi–sampi ≻ *n-osampi–nosampi	An inexact Reduplicant is chosen over one containing non-root material.
DISYLL ≫ R≤ROOT	no-naa–nonaa ≻ *no-naa–naa, n-apii–napii ≻ *n-apii–pii	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≤ROOT and MAX make exactly competing demands on the optimality of the Reduplicant. As we noted earlier (v. §5.3), the reversed ranking renders R≤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 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.