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Generalized alignment

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§1. Introduction

Overt or covert reference to the **edges** of constituents is a commonplace throughout phonology and morphology. Some examples include:

•In English, Garawa, Indonesian and a number of other languages, the normal right-to-left alternation of stress is interrupted word-initially:

(1) Initial Secondary Stress in English

(Tàta)ma(góuchee)	*Ta(tàma)(góuchee)
(Lùxi)pa(lílla)	*Lu(xìpa)(lílla)

As the foot-brackets ( ) indicate, the favored outcome is one in which the edge of the Prosodic Word coincides with the edge of a foot (cf. Liberman and Prince 1977:276).

•In Tagalog, the affix *–um–* falls as near as possible to the left edge of the stem, so long as it obeys the phonological requirement that its final consonant *m* not be syllabified as a coda:

(2) *–um–* Infixation in Tagalog

u.ma.ral		'teach'
s**u.m**u.lat	***um**.su.lat	'write'
gr**u.m**ad.wet	***um**.grad.wet	'graduate'

•In Ulwa, the affix *–ka–* 'his' falls immediately after the head foot of the word:

(3) *–ka–* Infixation in Ulwa

(bás)**ka**	'hair'
(siwá)**ka**nak	'root'

This affix is a suffix on the head foot, rather than on the word as a whole. That is, the affix lies at the right edge of that foot.

These examples only hint at the generality of the phenomenon to be explored here, which extends to include all the various ways that constituents may be enjoined to share an edge in prosody and morphology.

Data like these have been given widely disparate treatments in the literature: directionality of foot-parsing, syllabic or segmental extrametricality, and prosodic circumscription. Examination of a wider range of cases would reveal additional mechanisms claimed to depend crucially on the special status of constituent-edges: prosodic and morphological subcategorization, prosodic templates, and the cycle. These different ways in which constituent-edges figure in phonology and morphology would seem to make any effort at unification hopeless.

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Here we propose that the diverse ways in which constituent-edges figure in morphological and phonological processes can be subsumed under a single family of well-formedness constraints, called *Generalized Alignment*.

(4) Generalized Alignment

Align(Cat1, Edge1, Cat2, Edge2) $=_{def}$

$\forall$ Cat1 $\exists$ Cat2 such that Edge1 of Cat1 and Edge2 of Cat2 coincide.

Where

Cat1, Cat2 $\in$ PCat $\cup$ GCat

Edge1, Edge2 $\in$ {Right, Left}

PCat and GCat consist, respectively, of the sets of prosodic and grammatical (morphological or syntactic) categories provided by linguistic theory (see §2 below for one proposal). Thus, a GA requirement demands that a designated edge of each prosodic or morphological constituent of type Cat1 coincide with a designated edge of some other prosodic or morphological constituent Cat2. (We return below at the end of §2 to issues of formalization.)

For the examples cited above, for instance, the particular parametrization of GA is as follows:

(5) Generalized Alignment, Applied to (1)–(3)

a. English Stress

Align(PrWd, L, Ft, L) 'Each PrWd begins with a Ft.'

This requirement is satisfied in [(*Tàta*)*ma*(*góuchee*)], since the left edge of the Prosodic Word coincides with the left edge of a foot. (See §3 for the interaction of this type of constraint with others in the stress system.)

b. Tagalog *–um–*

Align($[um]_{Af}$, L, Stem, L) 'The affix *um* occurs stem-initially, is a prefix'

This requirement is satisfied in $|$***um****aral*, since the left edge of the affix *–um-* lies at the left edge of a stem. It is *minimally violated* (in a sense made precise below, §4) in $|$*s****um****ulat* or $|$*gr****um****adwet*.

c. Ulwa *–ka–*

Align($[ka]_{Af}$, L, Ft′, R) 'The affix *ka* follows, is a suffix to, the head foot.'

This requirement is satisfied in *(siwá)*$|$*–ka–nak,* from /siwanak+ka/, since the left edge of the affix $|$*ka* coincides with the right edge of the head foot, Ft′.

By virtue of statements like these, GA is able to express perhaps the full range of reference to edges in grammar. Taken together with X′-like restrictions on immediate domination and interpreted within the appropriate theory of constraint satisfaction, GA provides a mechanism for completely specifying a class of formal languages that, when substantive parameters are set, ought to be all-but-coextensive with possible human languages.

Because it is relatively abstract, and not tied to the particular details of a phonological or morphological sub-theory, GA has connections with more than a few other lines of analysis in the literature. The specific interpretation of GA as Align(GCat, PCat) has affinities with various approaches to phonological domains and apparent cyclic phenomena that involve simultaneous reference to prosodic and morphological structure: Liberman and Prince (1977:256-61), Aronoff and Sridhar (1983), Booij and Rubach (1984), Poser (1984), Booij (1988), Inkelas (1989), Szpyra (1989:178-229), Booij and Lieber (to appear), Rubach and Booij (1990), Halle and Kenstowicz (1991:479-81), Goldsmith (1990, 1991, 1992), Idsardi (1992), Cole (1992), Cole and Coleman (1992), Borowsky (to appear), and Kisseberth (to appear).

By simultaneous reference to prosodic and morphological constituents, GA also converges with the notion of prosodic subcategorization in Broselow and McCarthy (1983) and Inkelas (1989) and subsumes many aspects of prosodic circumscription in McCarthy and Prince (1990). With its focus on edges, GA further recalls 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 Pierrehumbert and Beckman (1988:126f.). More specifically, we will see in §3 below that it includes as special cases the family of constraints called ''EDGEMOST'' in Prince and Smolensky (1991ab, 1992, 1993). On a related theme, Burzio (1992ab) proposes a principle of Metrical Alignment, ''which essentially requires that the [English foot] parsing be left-hand exhaustive,'' with obvious similarity to (5a).

Certain familiar morphology/prosody correspondence schemes amount to demanding a kind of alignment at both edges simultaneously. In this class is the 'Prosodic Constituent Formation' of Inkelas (1989: 53), concisely $[x]_m \rightarrow [x]_p$ (where *p* represents a domain of phonological rule application, distinct from metrical structure, given formal constituent status in her theory). A further instance of simultaneous alignment is seen in the template-defining constraint format MCat=PCat, ''morphological category corresponds to phonological category'' of McCarthy and Prince (1991a), where *PCat* represents a prosodic category of metrical structure. In contrast to Inkelas (1989) and continuing the theme of McCarthy and Prince (1991a), we do not recognize a distinct third category of structure that provides a meeting ground for phonology and morphology; rather we argue that there is only metrical structure and morphological structure, which are related via the system of Generalized Alignment constraints. The crucial departure we advocate here is to allow separate control over the fate of each edge. We will see that conditions on left and right edges can indeed have very different grammatical status: cf. §5 below. (Application of Alignment to prosodic-morphological templates is taken up in McCarthy and Prince 1993:§7).

In conception, therefore, GA is most directly connected with the edge-based theory of the syntax-phonology interface (Chen 1987, Clements 1978:35, Hale and Selkirk 1987, Selkirk 1986, Selkirk and Tateishi 1988, Selkirk and Shen 1990). In this theory, the phonological representation of a sentence is constructed by rules that map the edges of syntactic constituents, such as the maximal projection of a lexical category, onto the corresponding edges of phonological constituents, such as the Phonological Word or Phonological Phrase. Cohn (1989) and Inkelas (1989) extend this model from syntactic to morphological constituents; for example, Cohn proposes a rule mapping the edge of the root onto the edge of a Phonological Word. In terms of the functional notation introduced in (4), the edge-based theory of sentence phonology reduces to Align(GCat, Edge1, PCat, Edge1), a mapping from the edges of grammatical categories onto the same edges of prosodic categories. Through GA, we extend this approach fully, so that opposite as well as corresponding edges can be aligned, and so that Align(PCat, GCat), Align(PCat, PCat), and Align(GCAt, GCat) are also licit expressions. Furthermore, we extend it to all GCat's, morphological as well as syntactic, and to all PCat's, including the word-internal prosodic categories syllable and foot, and even to features and subsegmental feature-geometric nodes, though these will not be discussed here.

One crucial aspect of the enterprise, without which this degree of abstraction would be impossible, is the idea that GA is embedded in a theory of constraints on the well-formedness of phonological and morphological representations, rather than a theory of rules or procedures for constructing representations. (This is a further respect in which GA is different from the edge-based theory of the syntax-phonology interface.[1]) Indeed, GA would fail utterly if it were cast in terms of operations rather than constraints. In standard accounts, the operations subsumed by GA are extraordinarily diverse; consider how different the procedures are for building phonological structure from syntactic structure, for parsing words into feet,

[1] Selkirk (1993) proposes an Optimality-Theoretic development of the edge-based theory of the syntax-phonology interface.

for prefixing an affix to a root, and for circumscribing the initial foot and suffixing to it. **As procedures**, these phenomena have nothing in common. The generality of Alignment is possible only in a system where it is imposed by constraints that evaluate the well-formedness of representations, without regard to the source of those representations.

A second crucial aspect of the enterprise, devolving from the first, is the idea that constraints on representation can be violated minimally, under specific conditions that compel violation. The case of Tagalog above is one example in which an Alignment constraint is minimally violated. For phonological reasons, the *m* of the affix *–um–* must not be syllabified as a coda. This phonological requirement takes precedence over Align([*um*]$_{\text{Af}}$, L, Stem, L), forcing mis-alignment of the affix-edge and stem-edge. But the departure from perfect Alignment is minimal, in the sense that the affix lies as near as possible to the designated edge, as can be seen by comparison of the actual forms with even more poorly aligned **sul**um**at* or **gradw**um**et*. Without the recourse of minimal violation, one would be forced to conclude that an analysis of Tagalog in terms of the constraint Align([*um*]$_{\text{Af}}$, L, Stem, L) is simply wrong, since this constraint is obviously unchallenged only in the occasional vowel-initial root like *aral*. GA, then, has a chance for success only if it is recognized that representational constraints need not be categorically true facts of a language.[2]

These two properties, which provide the foundation for GA, are the central claims of Optimality Theory (Prince and Smolensky 1991a, 1991b, 1992, 1993). OT is a general approach to the role of well-formedness constraints in linguistic theory, embodied in the following principles:

(6) Principles of Optimality Theory[3]

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.

Within OT, the role of a grammar is to select the output form from among a very wide range of candidates, including at least all of the outputs that would be possible in any language whatsoever. Thus, language-particular rules or procedures for creating representations have no role at all in the theory, and the entire burden of accounting for the specific patterns of individual languages falls on the well-formedness constraints. These constraints are ranked in a language-particular hierarchy; any constraint is violated, minimally, if such violation leads to the satisfaction of a higher-ranking constraint.

In the remainder of this article, we will show some of the principal results of GA. The discussion opens in §3 with an application of the alignment of prosodic categories to apparent directionality effects

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[2] The English constraint Align(PrWd, L, Ft, L) is also violated under various conditions, principally when main-stress falls on the peninitial syllable and the initial syllable is light, hence unfootable: *A(mán)da*, *po(líce)*, *A(méri)ca*. See §3 for discussion of related cases.

[3] A fourth, Parallelism, is not considered here.

Parallelism

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

See Prince and Smolensky (1993), McCarthy and Prince (1993) for discussion.

in stress systems. We then turn in §4 and §5 to alignment of morphological categories with one another and with prosodic categories. The subject of §4 is infixation phenomena as a specific case of the alignment of affixes, and the material of §5 is the alignment of prosodic categories at the edges of morphological ones, leading to a novel characterization of phenomena usually attributed to extrametricality, the cycle, or opacity of prosodic constituent-edges. Finally, §6 argues for constraints on the alignment of **different** edges of morphological and prosodic constituents, identifying them as a kind of prosodic subcategorization. The conclusion sums up the principal results. But first we must lay out some premises about the nature of prosodic and morphological constituency, and we must supply a more rigorous account of OT to serve as the basis for the analyses.

§2. Substantive, Formal, and Technical Assumptions

Generalized Alignment *per se* is independent of any specific set of assumptions about prosodic and morphological constituency, except of course that there is **some** such constituency. The consequences we draw from GA will, however, rely on making claims about how some particular constituent aligns with another. To make any progress, then, we must first commit to a theory of prosodic and morphological constituency. Our results will be most secure, however, if we adhere to a minimally elaborated theory, so that they emerge from the judicious application of Alignment rather than from some dubious cleverness in the assignment of the constituents themselves.

In the realm of prosody, the Prosodic Hierarchy (7), evolved from that of Selkirk (1980a, 1980b), is the simplest theory compatible with a very broad range of phenomena in the world's languages.

(7) Prosodic Hierarchy (McCarthy and Prince 1986, 1990, 1991a, b, 1993)

Prosodic Word	PrWd
	|
Foot	Ft
	|
Syllable	σ

Most phonological theories recognize an additional ''skeletal'' level, subordinate to the syllable, consisting of moraic (μ) or segmental (X) units (moraic: van der Hulst 1984, Hyman 1985, McCarthy and Prince 1986, 1988, Hayes 1989, Zec 1988, Itô 1989, etc.; segmental: McCarthy 1981, Steriade 1982, Clements and Keyser 1983, Levin 1985, Lowenstamm and Kaye 1986, etc.). We have not located any examples of Alignment constraints where PCat is a skeletal unit. This lacuna may be an accidental property of our sample. But it may reflect a deeper truth: the properties represented by the skeletal level — basically quantity and weight — are attributes of syllables and segments rather than constituents themselves (*cf.* Itô and Mester 1992). Whatever the explanation, the skeletal level is not treated further here (but see (37-38) below, p. 20).

The Prosodic Hierarchy expresses the domination relations among the prosodic constituents, but it does not express relations of immediate domination. Two departures from strict immediate domination are possible. First, because feet must be binary (Prince 1980, McCarthy and Prince 1986, Hayes 1991), single light syllables are normally unfooted and unfootable:

(8) Unfooted Singleton Syllables

[po(lice)]

[(Tata)ma(gouchee)]

Following Itô and Mester (1992) (*cf.* McCarthy and Prince 1993:§A.2), we assume that syllables are optimally parsed by the foot, and that otherwise syllables are parsed directly by PrWd, as shown by the outer brackets ‘‘[ ]’’ in (8). Second, we assume that recursion of PrWd is possible, as in English (Booij to appear: 137, McCarthy and Prince 1993:§A.1):

(9) Recursion of PrWd
[[light]$_{\text{PrWd}}$ [house]$_{\text{PrWd}}$]$_{\text{PrWd}}$
[[help]$_{\text{PrWd}}$ less]$_{\text{PrWd}}$ ness]$_{\text{PrWd}}$

Recursion of the categories foot and syllable is impossible, however, not because of some special stipulation, but because the independently justified foot and syllable theories of Universal Grammar bar it (foot: McCarthy and Prince 1986, 1990, 1993, Hayes 1987, 1991, Kager 1989, 1992a, 1992b, 1992c, etc.; syllable: McCarthy and Prince 1988, Hayes 1989, Itô 1986, 1989, etc.). Through their various principles, foot theory and syllable theory license a very limited set of expansions of foot and syllable, and recursion is simply not among these options. There is no theory placing comparable limits on the expansion of PrWd, and indeed there could not be, if only because there is no upper bound on the length of a PrWd. In this way, phonological theory permits recursion of PrWd only.

In the realm of morphology, the available options are much broader, ranging from constituent-free process models all the way to richly articulated X′ theories of word-syntax. If GA is to fly at all, we must assume **some** constituency, and if it is to be robust, we must not assume too much. (It is always easy to derive additional empirical results if more elaborated constituency turns out to be justified.) The hierarchy we assume is a traditional one, sufficient for present purposes:

(10) Morphological Hierarchy
MWd → Stem*
Stem → Stem, Affix
Stem → Root

The Morphological Hierarchy specifies constituency relations but not linear order of stem and affix. This move is essential in accounting for Prosodic Morphological phenomena like the Tagalog infix *–um–* (2) or the Ulwa infix *–ka–* (3). In morphology that is prosody-governed, phonological constraints take precedence over morphological ones (McCarthy and Prince 1993:§7); infixation shows that phonological constraints can determine even the linear order of morphemes and morpheme parts. Morphological structure represents a commitment only to the hierarchical organization of the constituent morphemes, not to linear ordering (*cf.* Sproat 1984:80f.) or continuity of the terminal string (*cf.* McCawley 1982, Scobbie 1991), so principles of phonology can affect linear order.

As noted above, an essential prerequisite to GA is Optimality Theory (Prince and Smolensky 1991a, 1991b, 1992, 1993), with its emphasis on selection of optimal output forms by a system of ranked, violable constraints. OT shifts the explanatory burden of linguistic theory from input-based rewrite rules to output-based constraints. Instead of taking an underlying form and transforming it stepwise to its associated ouput, in OT it is necessary to allow for the specification of a large set of *candidate* outputs. The candidate set is evaluated by the system of constraints, which selects the actual output from the available candidates. Schematically, the grammar is like this:

(11) An Optimality-Based Grammar, Schematically
Gen(in_i) = { cand_1, cand_2, …. }
Eval({cand_1, cand_2, ….}) → cand_k (the output, given in_i)

The function Gen associates each input with a (possibly infinite) set of candidate analyses of that input. Gen involves, for example, deployment of many different prosodic parses or many different linear arrangements of morphemes. The function Eval is defined by the system of constraints, which assesses the various candidate output forms, ordering the candidates by how well they satisfy the constraint system of the language. Any candidate from Gen(in_i) that best-satisfies the constraint system — a maximal element in the Eval ordering — is an output associated with the input in_i. Linguistic constraint systems typically associate just one output with a given input; therefore we will usually speak of 'the' output, even though it is possible in general for more than one form to best-satisfy a constraint hierarchy.

The central analytical proposal of OT is that constraints are ranked in a hierarchy of relevance. Lower-ranked constraints can be violated in an optimal output form when such violation secures success on higher-ranked constraints. Universal Grammar specifies the set of constraints Con out of which grammars are constructed. Individual grammars are constructed by imposing a ranking on the entire universal constraint set Con, possibly with some setting of parameters and fixing of arguments within the constraints, such as the various arguments of Align. UG thus consists of Gen, Con, and definition of how a ranking of Con imposes evaluation on forms.

To best-satisfy a system of ranked well-formedness constraints means the following. Except for ties, the candidate that passes the highest-ranked constraint is the output form. A tie occurs either when more than one candidate passes the highest-ranked constraint or when all candidates fail the highest-ranked constraint. As we will see, ties of both kinds are common. (Constraint violation is therefore not necessarily the end of a candidate's chances: failure on a constraint can be fatal only when there are other competitors that pass it.) In case of ties, all surviving candidates are tested recursively against the rest of the hierarchy. Once a victor emerges, the remaining, lower-ranked constraints are irrelevant; whether the sole surviving candidate obeys them or not does not affect its grammaticality. Likewise, the evaluation of failed candidates by lower-ranked constraints is also irrelevant; no inferences about degree of deviation from grammaticality can be drawn from further inspection of the failed candidates.

The following example illustrates schematically how satisfaction of a constraint hierarchy proceeds. Assume a grammar consisting of two constraints, A and B. Like any grammar, this one functions to pair underlying forms with surface forms: Eval(Gen(in_1)) → out_1, Eval(Gen(in_2)) → out_2, and so on. Suppose that we have a certain underlying form /in_k/ which gives rise to a candidate set {*k-cand*$_1$, *k-cand*$_2$} and that *k-cand*$_1$ is the actual output form.

If constraints A and B both agree that one candidate passes and the other fails, then there is nothing to say. The optimal candidate — the output associated with in_k — is just the one that meets both constraints, as in standard approaches to constraint satisfaction. If A and B **disagree**, however, we have a constraint conflict, represented by the following tableau:

(12) Constraint Tableau, A >> B, /in_k/ ↦ *k-cand*$_1$

Candidates	A	B
☞ k-cand$_1$		*
k-cand$_2$	* !	

Here candidate *k-cand*$_1$ meets A but fails B; while *k-cand*$_2$ meets B but fails A. Because *k-cand*$_1$ is, by assumption, the actual output form, the grammar requires that constraint A **dominate** constraint B — A >> B — in the sense that, when A and B disagree on a candidate-pair, the decision between them is

made by A alone. This tableau observes certain useful conventions: constraints are written in their domination order, violations are marked by ‘‘*’’, and **fatal** violations are also signalled by ‘‘!’’. Shading emphasizes the **irrelevance** of a constraint to the fate of the candidate. A loser’s cells are shaded after a fatal violation; the winner’s, when there are no more competitors.

There are a variety of other ways that a pair of candidates can confront constraints. There is the tying configuration mentioned above: if both candidates fail a constraint equally, or succeed equally on it, then that constraint cannot contribute to a decision between them; the decision, if there is one, must be made elsewhere, by other constraints. It is entirely possible that no-decision configurations can arise for both A and B in the above example; then the 2-constraint hierarchy does not decide between the candidates considered. Situations like this arise relatively rarely with respect to *whole* hierarchies in the real world, because of the richness of the constraints in Con, but are seen quite commonly in subhierarchies, as we will see below.

A particularly interesting configuration arises when a constraint in the grammar admits of multiple or gradient violation. Suppose we are looking at pair of candidates that tie on all constraints higher-ranked than C, and with C itself we have the following:

(13) Multiple Violation

Candidates	…	C
☞ $cand_1$	…	*
$cand_2$	…	***

In such a case, we say that $cand_1$ is the winner, because its accumulated violations of C are less than those of $cand_2$: C is violated **minimally**. Note that we are not **counting** the absolute number of violations; we are merely comparing more *vs.* less, a matter of ordering and not of quantity. Indeed, this case can be reduced to the first one by uniformly cancelling out violations one-for-one in the C-column, a procedure whose validity is proved in Prince and Smolensky (1993: §8). For further discussion and formalization see Prince and Smolensky (1993: §2, §5).

With these notions, we can compare any two forms *f* and *g* with respect to a constraint hierarchy or subhierarchy. If *f* fares better than *g*, we will say that *f* is more **harmonic** than *g* (with respect to the given hierarchy). If *f* and *g* fare equally, we will say that they are **iso-harmonic**. (The term ‘‘harmony’’ is from Smolensky 1986.) Eval thus provides a Harmonic Ordering of Forms, along the lines just reviewed (Prince and Smolensky 1993: §5). The output associated with a given input is the most harmonic member of the input’s candidate set, a maximal element in the harmonic ordering; we will say that it is **optimal**. In order to avoid terminological and conceptual confusion we will strictly avoid terms like ‘‘relative wellformedness’’ and ‘‘better/worse-formed’’, preserving the categorical status of the term ‘‘well-formed’’. A form *f* is **well-formed** with respect to a grammar if it is chosen by the grammar as the output for some input: if it is an optimal member of some candidate set.

The candidate analyses are drawn from a broad range of possibilities, supplied by Gen. Three principles underlie the theory of Gen assumed here, the first two taken from Prince and Smolensky (1993):

(i) **Freedom of Analysis**. Any amount of structure may be posited.
(ii) **Containment**. No element may be literally removed from the input form. The input is thus contained in every candidate form.
(iii)**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 nodes through fully specified vowels or consonants. Containment limits this freedom in one specific way: the input (the underlying representation) must be present in any licit candidate.

Freedom of Analysis is absolutely essential. 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 syllable’’ (that is, a rule of epenthesis), because Gen already, as it were, adds syllables. The constraint hierarchy of a given language exerts control over the teeming space of possibilities.

The **Containment** property has been assumed in all Optimality Theoretic analyses to date. (OT *per se* does not require it, but the effect is to make it possible to state all constraints on the output, without reference to the input-output relation.) It is similar but not identical to monotonicity in Categorial Phonology (Wheeler 1981, Bach and Wheeler 1981) or Declarative Phonology (Bird 1990, Scobbie 1992). Containment means, for example, that segmental deletion phenomena involve underparsing a segment of the input (e.g., ⟨*k*⟩*now*/*acknowlege*) rather than outright replacement of a segment by Ø. Respect for Containment entails, as indicated in (10), that infixal output candidates arise from inputs whose constituent morphemes are unspecified for linear order.

Consistency of Exponence, proposed in McCarthy and Prince 1993, is a specific hypothesis about the morphology-phonology relationship which is stronger than Containment. It means that the lexical specifications of a morpheme (segments, prosody, or whatever) can never be affected by Gen. In particular, epenthetic elements posited by Gen will have *no* morphological affiliation, even when they lie within or between strings with morphemic identity. Similarly, underparsing of segments — failure to endow them with syllable structure — 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.[4]

As final preparation for the analytical arguments to follow, we comment briefly on the technical role of the term ‘‘edge’’ in Alignment theory. The notion that we really need is relational, something like ‘‘sharing an edge’’, rather than categorical, referring to edge *per se*. Two categories are aligned when they ‘‘share an edge’’, and the Alignment constraint specifies the categories and which side of each is involved

[4] McCarthy and Prince (1993:§5.2) recognize one further articulation of this condition: a morpheme that has no phonological specifications at all in the lexicon (such as is the case with reduplicative affixes) takes as its exponent whatever phonological elements are associated with it in the output. Such morphemes are therefore formally *un*specified, rather than specified as containing nothing; morphemic exponents must be, in the classical manner, nondistinct at input and output. 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.

in ''sharing an edge''. To formalize this, we introduce the notion of a *concatenative decomposition* of a string:

(14) Dfn. Concatenative Decomposition.
A concatenative decomposition of a string S is a *sequence* of strings $\langle d_i \rangle_{j \le i \le k}$ such that $d_j \frown \ldots \frown d_k = S$.

The concatenative decompositions of a given string are numerous indeed, because any of the d_i may correspond to the empty string *e*, which has the property that $s \frown e = e \frown s = s$, for any string s. Compare the role of 0 in addition: 3+0 = 0+3 = 0+3+0 = 3. All these refer to the same number, but all are distinct as expressions. The notion ''concatenative decomposition'' allows us to distinguish among the different ways of expressing a string as a sequence of binary concatenations. We can now define the notion of ''sharing an edge'':

(15) Dfn. Sharing an Edge.
Let A, B be substrings of S. Let $\langle d_i \rangle_{1 \le i \le n}$ be a concatenative decomposition of S, such that for some subsequence $d_j,\ldots,d_k$ of $\langle d_i \rangle$, a subdecomposition, we have
$d_j \frown \ldots \frown d_k = A$
and for some subdecomposition $d_l,\ldots,d_m$ of $\langle d_i \rangle$ we have
$d_l \frown \ldots \frown d_m = B$.
If there is at least one such decomposition of S, such that $\{d_j,d_k\} \cap \{d_l,d_m\} \neq \emptyset$, then we say that A and B *share an edge*.

To see how this works, consider the case of S = AB. Here substrings A and B share an edge because there is a decomposition of S as $\langle d_1,d_2,d_3 \rangle$ where d_1 = A, $d_2 = e$, and d_3 = B. Since $A = d_1 \frown d_2$ and $B = d_2 \frown d_3$, we have d_2 as the shared element of the decomposition. Consider now the case of S and A. Since $S = d_1 \frown d_2 \frown d_3$, we have d_1 as the element of the decomposition shared by S and A, and it is follows that S and A also share an edge. This treatment shows that it is possible to develop a useful edge-predicate without a notion of edge as entity.[5]

At this point, it is straightforward to give a definition of Generalized Alignment. Let L be a function from decompositions to strings that returns the **first** element of a decomposition, and let R be a similar function that returns the last element. Then we have

(16) Dfn. Align(Cat1, Edge1, Cat2, Edge2).
Let Edge1, Edge2 be either L or R. Let S be any string. Then, for any substring A of S that *is a* Cat1, there is substring B of S that *is a* Cat2, such that there is a decomposition D(A) of A and a decomposition D(B) of B, both sub-decompositions of a decomposition D(S) of S, such that Edge1(D(A)) = Edge2(D(B)).

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[5] In stress theory, Halle and Kenstowicz (1991) and Idsardi (1992) take a different approach to establishing the coincidence of constituent edges. They propose to reify the constituent boundary-symbols; for example, in Diyari (*cf.* Poser 1989), where the left edge of each morpheme must coincide with the left edge of a foot, Halle and Kenstowicz propose a rule inserting a left foot-bracket symbol at the left edge of each morpheme. This reification of boundary symbols is sharply at odds with other work which, beginning with Siegel (1974), Rotenberg (1978), and Selkirk (1980a), has rejected boundary-symbol theory elsewhere in phonology and morphology. It is essentially an artifact of commitment to the idea that phonological representations are literally *built* by rule, and indeed rules of string manipulation. The alternative is to view phonological representations like those of syntax: they conform to (a system of) constraints defined over constituency.

The interest of this construction is that the notion ‘‘edge’’ does not appear as a referential term anywhere in it; the only notions deployed are those of constituency (‘‘is a’’) and the ordinary predicates of string theory. In what follows we shall make free use ‘‘edge’’ as a term of convenience in various locutions, and we shall make use of brackets and parentheses as handy notational tools to jog the eye and the imagination, but the actual theory deals only in strings of motivated elements and their motivated constituency.

§3. Constraints on Prosodic Edges: Align(PCat, PCat)

The alignment of the edges of prosodic constituents provides the first example of GA that we will examine in depth. By demonstrating the role of Alignment constraints in prosody proper, it complements the cases of morphological and morphophonological Alignment discussed in subsequent sections. Thus, this evidence contributes to demonstrating the true generality of GA.

To simplify the exposition by limiting the profusion of candidates under consideration, we will assume that certain constraints are undominated and therefore (because Gen always happens to provides candidate that satisfy them) unviolated in the languages under discussion. These constraints, which are treated by Prince and Smolensky (1993:§4) and McCarthy and Prince (1993:§A.2), include the following:

(17) FT-BIN (Prince 1980, McCarthy and Prince 1986, 1991a, 1993)
Feet must be binary under syllabic or moraic analysis.

Since our empirical focus will be limited to a rhythmically narrow range of systems, we note that the following holds of all admitted feet:

(18) FOOT-FORM (TROCHAIC)
$\text{Ft} \rightarrow \sigma_s\ \sigma_w$

This foot-type is familiar as the syllabic trochee, a quantity-insensitive foot, which makes no distinctions of syllable weight.[6] (For recent discussion see Hayes 1991, Kager 1992a, 1992b, 1992c.) Another constraint assumed to hold quite generally is PARSE-SYLL:

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

PARSE-SYLL is a familiar aspect of stress theory (e.g., Liberman and Prince 1977:266, 294; Prince 1980:535; Halle and Vergnaud 1987; Hayes 1987), corresponding broadly to the requirement that foot-parsing be ‘‘exhaustive’’ in rule-based metrical phonology.

We assume the dominance of FT-BIN over PARSE-SYLL, so that exhaustive footing cannot be achieved through the use of unit feet. This dominance relation is quite normal, and if universal, would entail that FT-BIN should be incorporated into Gen. (For relevant discussion, see e.g. McCarthy and Prince 1986, 1990; Hayes 1991, Kager 1993, Kiparsky 1992.) We will also assume that the size and syllabic composition of the Prosodic Word is fixed for any given input form by superordinate principles of syllabification on the one hand and interface on the other, so it cannot vary among candidates derived

[6] The constraints determining the headedness of feet can also be expressed in terms of GA. Trochaicity is Align(Ft, L, H(Ft), L), where H(Ft) = ‘‘head of foot’’ = strongest syllable-daughter of F. See (35-36), below p. 18, for further discussion.

from that form. In particular, we exclude from considerations candidates with epenthetic syllables and those with multiple PrWd's dividing up a single morphological word. For discussion of the syllabification principles, see Prince and Smolensky (1993: §6); of the interface, see McCarthy and Prince (1993: §4).

Given these strictures, the foot-parsing imposed on an even-parity input /σσσσσσ/ is uniquely determined: [(σσ)(σσ)(σσ)], where ''[…]'' indicates PrWd constituency and ''(…)'' indicates foot constituency. All syllables are parsed into feet, and all feet are binary: since all constraints are met, nothing can be more harmonic. For an odd-parity input of sufficient length, however, various possibilities are attested among the world's languages:

(20) Trochaic Stress Patterns, Schematically

a. L→R Pattern: Wankumara (McDonald and Wurm 1979:5, Hayes 1991)
[(σ́σ)(σ́σ)(σ́σ)σ̲]

b. R→L Pattern: Warao (Osborn 1966:114-5, Hayes 1980, 1991)
[σ̲(σ́σ)(σ́σ)(σ́σ)]

c. ''Initial Dactyl'' — Initial Trochee + R→L: Garawa (Furby 1974, Hayes 1980, 1991))
[(σ́σ)σ̲(σ́σ)(σ́σ)]

d. L→R + Final Trochee: Polish (Rubach and Booij 1985)
[(σ́σ)(σ́σ)σ̲(σ́σ)]

Observe that PARSE-SYLL is violated, albeit minimally, in all these forms. The dominance of FT-BIN ensures this, as the following tableau illustrates:

(21) Necessity of PARSE-SYLL Violation in Odd-Length Strings

Candidates	FT-BIN	PARSE-SYLL
☞ (σσ)σ		*
☞ σ(σσ)		*
(σσ)(σ)	* !	
(σ)(σσ)	* !	

The nonuniqueness of optimality highlights the fact that other principles must be at play to decide among the minimal violators.

The verbal descriptions of the various attested patterns of forced nonparsing are based on the classification in standard rule-based treatments (Prince 1976, 1983, Hayes 1980, 1991). In rule-based metrical theory, the L→R pattern (20a) and the R→L pattern (20b) are seen as evidence for a directional sweep of foot-parsing, first pairing-up the leftmost (or rightmost) couple of syllables, then moving on to do the same to the remaining chunk of the word.[7]

[7] In contrast, there seems to be little or no evidence of directionality in iambic foot-parsing. McCarthy and Prince (1993:§A.2) show that specification of directionality in iambic foot-parsing is superfluous, given avoidance of final stress, NONFINALITY. In the current context, this result must mean that the Alignment constraints enforcing

This input-driven iterative foot-parse is impossible in OT, with its commitment to evaluating candidate output forms. It also runs afoul of the facts in (20c, d), in which pure directional iteration is compromised by a single trochee lying at the opposite end of the PrWd. (In rule-based metrical phonology, (20c, d) are accounted for by first laying down a single foot at one end, then iterating from the other.) Instead of iteration, GA supplies a set of output constraints that precisely control this interlinguistic variation.

We begin with the so-called ‘‘initial dactyl’’ stress pattern (20c), which illustrates all of the essential elements of this application of GA. Stress in Garawa respects the following generalization:

(22) Stress in Garawa, Descriptively (Furby 1974, Hayes 1980, 1991)
–Main stress falls on the initial syllable;
–secondary stress falls on the penult;
–tertiary stress falls on every other syllable preceding the penult (but not on the peninitial)

Attested PrWd’s of Garawa are generously long, so the pattern is particularly easy to see, as the following foot-parsings show:

(23) Foot-Parsing in Garawa

[(σ́σ)]	yámi	‘eye’
[(σ́σ)**σ**]	púnja.**la**	‘white’
[(σ́σ)(σ́σ)]	wátjim.pàŋu	‘armpit’
[(σ́σ)**σ**(σ́σ)]	káma.**la**.řìnji	‘wrist’
[(σ́σ)(σ́σ)(σ́σ)]	yáka.lâka.làmpa	‘loose’
[(σ́σ)**σ**(σ́σ)(σ́σ)]	ŋánki.**ři**.kîrim.pàyi	‘fought with boomerangs’
[(σ́σ)(σ́σ)(σ́σ)(σ́σ)]	ŋámpa.lâŋin.mûkun.jìna	‘at our many’
[(σ́σ)**σ**(σ́σ)(σ́σ)(σ́σ)]	náři.**ŋin**.mûkun.jîna.mìřa	‘at your own many’
[(σ́σ)(σ́σ)(σ́σ)(σ́σ)(σ́σ)]	nímpa.lâŋin.mûku.nânji.mìřa	‘from your own two’

Since the goal here is to account for the foot-parsing only, the degrees of stress will be ignored.

One observation is immediately apparent from (23): the first two syllables of the PrWd are footed together, whatever the disposition of the rest of the word. This is a typical Alignment effect, obtaining between the two prosodic categories foot and PrWd:[8]

(24) ALIGN-PRWD (Garawa)
Align(PrWd, L, Ft, L)

That is, the left edge of each PrWd must match the left edge of some foot. This is a matter of empirical, not logical, necessity, as shown by the comparison of competing candidate parses for a trisyllabic or other odd-parity input (*cf.* (21)):

directionality of foot-parsing are always low-ranking relative to NONFINALITY.

[8] For broadly similar approaches to phenomena of this sort, see Burzio (1992a, 1992b), Idsardi (1992). An exact parallel is found in Itô and Mester (1992).

(25) Application of ALIGN-PRWD

	Align
☞ [(σσ)σ]	✓
[σ(σσ)]	*

In the first candidate, the left edge of PrWd does indeed coincide with the left edge of a foot, satisfying Align(PrWd, L, Ft, L). In the second candidate, though, the left PrWd-edge coincides with the left edge of a syllable, but not of a foot. Hence, the first candidate is optimal. The same logic holds trivially for disyllables and can be extended readily to polysyllables of indefinite length.

In the terms of Prince and Smolensky (1991ab, 1992, 1993), such relations are established by a constraint EDGEMOST, defined by them as follows:

(26) EDGEMOST(φ;E;D)
The item φ is situated at edge E of domain D. (Prince and Smolensky 1993: 35)

It should be clear that this is rendered by the GA scheme ALIGN(φ,E,D,E), where φ is a daughter of D. In the case at hand, we have EDGEMOST(F;L;PrWd) as the correlate of ALIGN(PrWd, L, Ft, L). GA is more general in two respects: it does not restrict the hierarchical relation of Cat1 and Cat2; and it does not require sameness of the shared edge. Thus, GA subsumes EDGEMOST.

There is also an Alignment effect at the **right** edge of Garawa PrWd's. This is apparent from the odd-parity forms in (23) containing five or more syllables. Five syllable words, for example, are parsed (σσ)σ(σσ), with right Alignment, rather than *(σσ)(σσ)σ. This phenomenon also requires a constraint enforcing Alignment of foot and PrWd:

(27) ALIGN-FT (Garawa)
Align(Ft, R, PrWd, R)
''Every foot stands in final position in the PrWd.''

ALIGN-FT differs from ALIGN-PRWD in two respects. One is obvious: the edges, left or right, that must be aligned. The other much less so: the order of constituent arguments is reversed, Align(PrWd, Ft) at the left edge, Align(Ft, PrWd) at the right edge. This move is crucial, as we will show shortly, since it permits Alignment, within OT, to supplant both the non-iterative and the iterative operations of standard rule-based metrical phonology.

ALIGN-PRWD and ALIGN-FT are in conflict in trisyllables. In OT, constraint conflicts lead to constraint violations, and from the resolution of the conflict the ranking relation between the conflicting constraints can be determined. The following tableau presents an argument for ranking these two constraints:

(28) ALIGN-PRWD >> ALIGN-FT, from /σσσ/

Candidates	ALIGN-PRWD	ALIGN-FT
a. ☞ [(σ́σ)σ]		*
b. [σ(σ́σ)]	* !	

The candidate (28b) violates ALIGN-PRWD, since the PrWd and the first foot do not commence together. It is, however, properly aligned on the right edge. In contrast, the candidate (28a) is well-aligned on the left and ill-aligned on the right. Thus, ALIGN-PRWD and ALIGN-FT are in conflict. Since (28a) is the actual output form, the conflict is resolved in favor of ALIGN-PRWD and at the expense of ALIGN-FT, proving that ALIGN-PRWD >> ALIGN-FT.

The optimal placement of a single foot in trisyllables is not the only circumstance when ALIGN-FT is violated. Recall the definition of GA from (4). Align(Cat1,…, Cat2,…) quantifies **universally** over the edges of tokens of Cat1 and **existentially** over the edge of some Cat2. **Every** Cat1 must share an edge with **some** Cat2. The two Alignment constraints of Garawa, then, have the following sense when spelled out:

(29) Alignment in Garawa
- a. ALIGN-PRWD: Align(PrWd, L, Ft, L)
  Any $[_{PrWd}$ is aligned with a $(_{Ft}$.
- b. ALIGN-FT: Align(Ft, R, PrWd, R)
  Any $)_{Ft}$ is aligned with a $]_{PrWd}$.

ALIGN-PRWD is satisfied by any PrWd that begins crisply on a foot-edge — in fact, all the PrWd's of the language begin so, because, as was just shown, ALIGN-PRWD is undominated. But ALIGN-FT is violated by every foot that is not final in PrWd, so violations of it occur not only in trisyllables, but in all words of (23) containing more than one foot.

It might seem that a constraint that is violated so freely is of little use, but this is far from the truth. Pursuing an observation made to us by Robert Kirchner about EDGEMOST, we can see that ALIGN-FT is not a coarse sieve straining out non-final feet, but rather, through the Optimality-Theoretic imperative to violate constraints **minimally**, a fine mesh that subsumes the effects of directional iteration in rule-based theories. Prince and Smolensky propose that violation of EDGEMOST is gradient, with degree of violation measured by the distance of φ from the designated edge. The examples discussed by Prince and Smolensky typically involve applying EDGEMOST to a unique element, like a single affix or the prosodic head of a word, but Kirchner notes that if EDGEMOST applies to every foot, then it will minimize the distance of each foot from a designated edge — exactly as in directional iteration of foot-building. GA leads directly to this result. Because ALIGN-FT quantifies universally over tokens of foot, all instances of foot in some PrWd must be evaluated for the goodness of their alignment with the PrWd's right edge. The pattern with minimal violation is optimal, where the minimally violating pattern is the one in which no right foot-edge could lie any closer to the right PrWd-edge.

Given our assumptions about preconditions on the candidates to be considered (PARSE-SYLL, FT-BIN, and so on), the following list includes all of the admissible parses of a heptasyllable:

(30) Heptasyllabic Parses
- a. [(σ́σ)(σ́σ)(σ́σ)σ]
- b. [(σ́σ)(σ́σ)σ(σ́σ)]
- c. ☞ [(σ́σ)σ(σ́σ)(σ́σ)]
- d. [σ(σ́σ)(σ́σ)(σ́σ)]

The actual Garawa pattern is marked as optimal. Of these candidates, (30d) can be dismissed immediately, since it violates ALIGN-PRWD, an undominated constraint, as was shown above in (28). The remaining candidates differ in the disposition of non-initial feet in a way that can be derived from ALIGN-FT. The table (31) categorizes each individual foot of the candidate forms for degree of violation of ALIGN-FT.

(31) Comparison of Heptasyllabic Parses by ALIGN-FT

	Ft-1	Ft-2	Ft-3
a. [(σ́σ)$_1$ (σ́σ)$_2$ (σ́σ)$_3$ σ]	σσσσσ	σσσ !	σ !
b. [(σ́σ)$_1$ (σ́σ)$_2$ σ (σ́σ)$_3$]	σσσσσ	σσσ !	Ø
c. ☞ [(σ́σ)$_1$ σ (σ́σ)$_2$ (σ́σ)$_3$]	σσσσσ	σσ	Ø

Violation of ALIGN-FT is gradient, not Boolean, so each foot is judged by the distance of its right edge from the right edge of the PrWd. Degree of violation is indicated graphically by the string of syllables separating the right edge of the foot under consideration from the right edge of the PrWd. The optimal candidate is the one whose constituent feet violate ALIGN-FT the least. Comparison of the rightmost foot is sufficient to eliminate the candidate (31a), whose last foot is non-final. Comparison of the penultimate foot eliminates all candidates except (31c), which is the actual output. In sum, ALIGN-FT quantifies over all the feet in a word, evaluating each for its fitness. Observe that it is not necessary to distinguish the violations by the foot that is responsible for them, as in table (31); aggregating the entire set of them gives the same results. The foot-by-foot breakdown is shown for purposes of clarity only.

Consideration of a wider field of candidates than in (31) does not change the outcome. As was already noted, the form (30d) violates dominant ALIGN-PRWD. Otherwise it would be superior in terms of ALIGN-FT even to the actual output (31c), showing that ALIGN-PRWD and ALIGN-FT conflict crucially in any odd-parity word, not just in trisyllables like (28). Less complete parsings, such as [(σ́σ)σσσ(σ́σ)], would also be superior on grounds of ALIGN-FT to the actual output form, but these would contravene the assumption that PARSE-SYLL is satisfied maximally in all legitimate candidates, subject only to dominant FT-BIN. Finally, it is logically possible to satisfy both constraints fully with complex PrWd parses like [[(σ́σ)][(σ́σ)][(σ́σ)]] or [[[(σ́σ)](σ́σ)](σ́σ)], imposing a multiple-PrWd structure on a single stem, but this too contravenes one of the initial assumptions introduced at the outset of the discussion.

We have shown, then, that Align(Ft, PrWd) subsumes the properties of directional iteration of foot assignment in rule-based metrical phonology. Quantifying over all instances of *foot* in a PrWd and evaluating each gradiently for alignment yields a system in which each foot lies as close as possible to the designated PrWd-edge. In contrast, Align(PrWd, Ft) quantifies universally over PrWd's, requiring only that there be **some** foot which is left-aligned, not that **all** feet be left-aligned. If Align(X, Y) held of every Y as well as every X, then all distinction would be lost between ALIGN-PRWD and ALIGN-FT, and whichever was dominant would completely overrule the other, rendering the subordinate constraint inactive in the grammar. In the case of Garawa, there would be no way to express the difference in status between right-edge and left-edge footing. This result illustrates the need for a crucial asymmetry in the definition of GA (4): universal quantification over the first constituent argument, existential quantification over the second.

A fundamental claim of OT is that languages differ principally in the ranking they impose on constraints. Permuting the ranking of these two senses of Align, combined with different parameters of the left or right edge, generates exactly the trochaic typology in (20):

(32) Trochaic Stress Patterns, Analyzed

a. L→R Pattern: [(σ́σ)(σ́σ)(σ́σ)σ]
   Align(Ft, L, PrWd, L) >> Align(PrWd, R, Ft, R)

b. R→L Pattern: [σ(σ́σ)(σ́σ)(σ́σ)]
   Align(Ft, R, PrWd, R) >> Align(PrWd, L, Ft, L)

c. ''Initial Dactyl'' — Trochee + R→L: [(σ́σ)σ(σ́σ)(σ́σ)]
   Align(PrWd, L, Ft, L) >> Align(Ft, R, PrWd, R)

d. L→R + Final Trochee: [(σ́σ)(σ́σ)σ(σ́σ)]
   Align(PrWd, R, Ft, R) >> Align(Ft, L, PrWd, L)

Patterns (32c) and (32d) are left/right mirror images of one another, the former exemplified by Garawa, which we have seen, and the latter by Polish.

In the patterns in (32a,b), the constraint Align(Ft, PrWd) is dominant. This constraint evaluates all feet, requiring that they lie as close as possible to the PrWd edge. In contrast, Align(PrWd, Ft) looks at only a single foot, which should also lie near the PrWd edge. Since Align(Ft, PrWd) applies to all feet, while Align(PrWd, Ft) applies to just one, the ranking Align(Ft, PrWd) >> Align(PrWd, Ft) renders the lower-ranking constraint invisible — it can have no observable effect on the well-formedness of representations, so the pure L→R or R→L pattern is obtained.

(33) Align(Ft, R, PrWd, R) >> Align(PrWd, L, Ft, L) in Warao (20b)

Candidates	Align(Ft, PrWd)	Align(PrWd, Ft)
a. ☞[σ(σ́σ)(σ́σ)]	Ft-1: σσ Ft-2: Ø	*
b. [(σ́σ)σ(σ́σ)]	Ft-1: σσσ ! Ft-2: Ø	

The initial foot of (33b) is inferior, on grounds of ALIGN-FT, to the initial foot of (33a). Since the ALIGN-FT constraint is dominant, this inferiority is fatal, and so the lower-ranking ALIGN-PRWD constraint can have no effect.[9]

The typology can be extended further by permuting the ranking of Alignment with respect to the constraint PARSE-SYLL (19), which demands maximal parsing of syllables into feet, as in all the candidates examined thus far. If Align(Ft, R, PrWd, R) >> PARSE-SYLL, then the optimal candidate is [σσσσσ(σ́σ)], with a single foot lying at the right edge:

[9] This masking of the more specific constraint when dominated by a more general one is an instance of Pāṇini's Theorem on Constraint Ranking (Prince and Smolensky 1993:§5.3).

(34) Align(Ft, R, PrWd, R) >> PARSE-SYLL, Applied to /σσσσ/

Candidates	Align(Ft, PrWd)	PARSE-SYLL
a. ☞ [σσ(σ́σ)]		*
b. [(σ́σ)(σ́σ)]	* !	

The penultimate foot of (34b) violates Align(Ft, R, PrWd, R). The degree of violation doesn't matter, since the other candidate (34a) is perfectly aligned, simply by virtue of positing only a single foot.[10] Thus, the pattern of ''non-iterative'' foot-parsing can be obtained from a low ranking of PARSE-SYLL.

In principle, the typology should also be extensible by considering different arrangements of the edge (left or right) parameters than those considered in (32), but in practice no new stress patterns are obtained. For example, the grammar Align(PrWd, L, Ft, L) >> Align(Ft, L, PrWd, L), with two separate Alignment requirements imposed on the same edge, yields the same result as (32a). And constraints like Align(PrWd, L, Ft, R) or Align(Ft, R, PrWd, L) have no sensible interpretation, since alignment of different edges is impossible between a pair of constituents of which one contains the other in a hierarchy.[11] (Alignment of different edges is, however, essential to characterizing other phenomena discussed below in §4 and §6.)

To complete the discussion of elementary stress-pattern theory, we observe that one foot must typically be picked out as the strongest, the head of the PrWd Ft′. (A further distinction between secondary and tertiary stress, as in Garawa, is often not represented phonologically in contemporary discussions.) This task is commonly assigned to the *End Rule*, or in the work of Prince and Smolensky, the constraint EDGEMOST which generalizes the End Rule. As noted above, GA includes EDGEMOST, and here again we call on Alignment:

(35) ALIGN-HEAD
Align (PrWd, Edge, H(PrWd), Edge)

In Garawa, we have Edge = L, and the constraint does not interact with the two Alignment constraints discussed above, which unambiguously fix the foot pattern by themselves. English, if we assume the

[10] In cases like (34), where a viable candidate does not violate the gradient constraint at all, we do not bother to show the degree of violation for remaining candidates.

[11] The one situation where this could arise would be with recursion of PrWd. A constraint like Align(PrWd, L, F, R) — the initial edge of the PrWd must align with the final edge of a foot — is met by the subordinate PrWd in a structure like [(σσ **)[** (σσ)(…)]]. However, the topmost PrWd violates the constraint, and on the assumption that there is always a single PrWd analysis [(σσ)(σσ)(…)]], it may well be that success on the subordinated PrWd is not relevant to harmonic evaluation. Suppose that comparative evaluation of PrWd status proceeds on a ''worst-first'' basis — match worst, then next worst, etc. Then both forms tie on the topmost PrWd, which fails the constraint; what's left in each passes the constraint, vacuously if there is no PrWd, so that the decision must be passed to other constraints. Among the others will be *STRUC, which penalizes all structure (Prince and Smolensky 1993:§3), so that the single-PrWd analysis will always win.

characterization in §1 above, shows the same broad pattern of footing as Garawa, guaranteed by ALIGN-PRWD >> ALIGN-FT, but in English ALIGN-HEAD, with Edge = R, must dominate ALIGN-PRWD:[12]

(36) English-type System

Candidates	ALIGN-HEAD	ALIGN-PRWD
☞ [Ma(níla)]		*
[(Máni)la]	* !	

The head-alignment constraint has obvious cognates in both morphology and syntax, presumably to be expressed in the same way. Observe that the order of arguments in the constraint Align(Cat, Edge, H(Cat), Edge) guarantees that for every Cat **there is** a corresponding H(Cat), in accord with the requirement that categories be headed. If we reverse the order, the constraint is vacuously satisfied in headless constituents.

The broad scope of GA can be seen by considering alignment of categories other than PrWd and foot. It is impossible to explore all ramifications fully here, but a sketch of the possibilities proves interesting:

•Align(PrWd, σ). This requires that any PrWd-edge coincide with a syllable-edge. With sufficiently high rank in some language, and specified for a particular edge, it will prohibit free-standing extrasyllabic segments, assuming that these are parsed by PrWd, as in Rubach and Booij (1990).

•Align(Ft, σ). This requires that every foot-edge align with the edge of a syllable. When visibly active, it bars foot-level appendices, if indeed Gen supplies any such, and ambisyllabicity between feet, as in English (Kahn 1976, *cf.* Kiparsky 1979).

•Align(σ, PrWd), Align(σ, Ft). If ranked below PARSE-SYLL, these constraints have no visible effect. If ranked above it, however, they assert that each PrWd or foot must consist of a single syllable. (That single syllable must be heavy, by FT-BIN.) Thus, these constraints could provide a characterization of the monosyllabic template in Prosodic Morphology (*cf.* McCarthy and Prince 1993:§7).

•Align(σ, L, σ, R). This constraint captures much of the import of the Peripherality Condition on extraprosodicity (Harris 1983, Hayes 1980, 1991; *cf.* Inkelas 1989:191f.). If the left edge of each syllable must coincide with the right edge of another syllable, then syllables should come one after the other in a chain uninterrupted by free-standing unsyllabified elements. The leftmost syllable is inevitably ill-aligned, and the constraint says nothing whatsoever about what must follow the rightmost syllable, so it allows such PrWd-parsed elements to occur freely at either end of the relevant domain. The choice of aligning edges as L,R vs. R,L seems to be of no importance.

In this section, we have examined a variety of structures that are defined by interaction of constraints of the form Align(X,Y), where X and Y are drawn from the prosodic hierarchy. Our purpose

[12] We have chosen an example where nonfinality effects ('extrametricality') are irrelevant. For recent discussion of this phenomenon and its interaction with alignment/edgemostness see Prince and Smolensky (1993), Hung (1993).

has been both to illustrate with specific cases how GA works under OT and to shed some new light on the empirical matters under discussion. Stepping back a bit, we can see that the effects of ALIGN fall into three basic classes, depending on the hierarchical relation between the categories mentioned in the constraint:

A. Align(X,y) where *X* dominates *y*. Example: Align (PrWd, Ft).

B. Align(y,X), where *X* dominates *y*. Example: Align (Ft, PrWd)

C. Align (x,y) where *x* and *y* are at the same hierarchical level. Example: Align(σ, σ)

The focus has been on types (A) and (B), particularly their role in stress systems.

In Align(X,y) the requirement is that every instance of superordinate X must share a designated edge with some instance of subordinate y. Examples reviewed above include foot at the edge of PrWd, syllable at the edge of PrWd, σ at the edge of foot. Align(X,y) says nothing about the alignment or existence of other instances of y inside X. With very visible effects in such languages as Garawa, Indonesian, and English, the constraint Align(PrWd, L, Ft, L) demands that each PrWd begin with a foot; but the constraint has nothing to say about the other feet in the word.

The constraint Align(y,X) controls the disposition of every *y* in category *X*. Specifically, Align(y,X) says that every *y* must stand at the designated edge of superordinate *X*. A constraint like Align(Ft, R, PrWd, R) requires that **every** foot be final in a PrWd. Perfect satisfaction can be obtained only when there is exactly one Ft per PrWd. The PrWd is therefore **minimal** with respect to its expansion into feet. By the same token, Align(σ,PrWd) enforces monosyllabicity. Thus, the constraint Align(y,X) yields a formalization of the different versions of minimality called on in prosodic-morphological systems (McCarthy and Prince 1991ab). A further interesting variant of Align(Ft, PrWd) arises if there is no constraint active to limit the division of a base into many PrWd's: then parsing can impose a number of minimal PrWd's, each containing no more than one Foot, exactly as in the ''Vertical Maximization'' of Hewitt (1992).

The most striking effects occur, however, under the regime where only one PrWd is allowed per base. Violation of Align(Ft, PrWd) can be compelled by dominant PARSE-SYLL, which demands the presence of feet to license syllables. (More generally, violation of any Align(y,X) can be forced by a higher-ranking constraint of the PARSE variety, forcing multiple occurences of the subordinate category y in X.) In such cases, in accord with Kirchner's insight into the effect of cumulative violations on foot-sequencing, the fundamental Optimality-Theoretic principle of *minimal violation* will require that each foot (or each y) be stationed as near as possible to the designated edge of the PrWd (or category X), yielding the pattern of apparently directional parsing that is so familiar from metrical stress theory.

In the examples considered above, the constituent against which the Foot is aligned is always the prosodic category PrWd. In these cases, alignment of Foot against PrWd is appropriate because of the lack of morphological conditioning of stress, such as apparent cyclicity. Replacing PrWd by one of the morphological categories Root or Stem in the alignment constraint will produce effects of the kind often attributed to the cycle. This is explored in Cohn and McCarthy (in prep.), and may be compared to broadly similar approaches to dispensing with cyclicity of stress or accent in Cole (1992, 1993), Cole and Coleman (1992), Goldsmith (1990, 1991, 1992), Idsardi (1992), and Kisseberth (to appear).

Finally, it is worth noting that fundamental constraints like ONSET ''syllables have onsets'' and NO-CODA ''syllables do not have codas'' (cf. Prince and Smolensky 1993:§6) can be given an align-theoretic formulation:

(37) ONSET

Align (σ,L,C,L)

(38) NO-CODA

Align(σ,R,V,R)

Unlike the prosodic constraints reviewed above, these show a distinct lack of free combination of argument-settings. Here GA provides a way of formalizing the substantively-fixed constraints. In higher-order prosody, however, free choice of the Alignment parameters maps out an entire typology of systems and interactions.

§4. Generalized Alignment and Infixation

Recall the *um*-infixation phenomenon in Tagalog, introduced above in §1. The examples, repeated below in (39), show that this infix falls before the first vowel of a word:

(39) Tagalog –*um*– Infixation

Root	–um–	
/aral/	/um–aral/	‘teach’
sulat	s–um–ulat	‘write’
gradwet	gr–um–adwet	‘graduate’ (French 1988)

The goal is to provide an account of the distribution of this affix within OT and ultimately to relate this account to a general theory of infixation.

One approach to Tagalog and similar cases is **prosodic circumscription**, proposed in McCarthy and Prince (1990). In prosodic circumscription, there is a parsing function Φ(B, C, E) which returns the designated prosodic constituent C that sits at the edge E of the base B. The function Φ induces a factoring on the base B, dividing it into two parts: one is the kernel B:Φ, the part that satisfies the constraint (C, E); the other is the residue B/Φ, the complement of the kernel within B.[13] Assuming an operator ‘‘*’’ that gives the relation holding between the two factors (normally left- or right-concatenation), the following identity holds:

(40) Factoring of B by Φ

$$B = B{:}\Phi * B/\Phi$$

In **negative** prosodic circumscription, the residue B/Φ of the parse is submitted to the morphological operation. Thus, O/Φ(B) — the application of O to the base B minus some edge constituent — is defined as follows:

(41) Definition of Operation Applying Under Negative Prosodic Circumscription

$$O/\Phi\,(B) = B{:}\Phi * O(B/\Phi)$$

In these terms, Tagalog –*um*– infixation is a case of negative prosodic circumscription. The circumscriptional function is parametrized as Φ(Consonant, L), and the morphological operation O as ‘‘prefix –*um*–’’.

Two types of problems beset this circumscriptional analysis. Loanwords like *gr–um–adwet* present obvious empirical difficulties. If the Onset is not recognized as a category of prosody, then there is no actual constituent to substitute for C in Φ(C,E) (*cf.* Anderson 1992). If Onset is admitted as a constituent, then it is not possible to explain why words with initial clusters, recently borrowed into various Austronesian languages, consistently infix like *gr–um–adwet* and never like **g–um–radwet*. If Onset were

[13] Using standard functional notation, the kernel is Φ(B) and the residue is B–Φ(B). We use B:Φ and B/Φ (respectively) for notational convenience and perspicuity.

a constituent type, we would expect to find a free choice between circumscribing the whole Onset or just the initial consonant. But there is no choice: it is never just the initial consonant, but always the maximal initial cluster.

Negative circumscription also fails to explain why it is just exactly a VC-shaped affix that is found in prevocalic position. From the phonological point of view, locating a VC affix before a vowel makes good sense, since it is consistent with an unmarked …CVCV… syllable structure, as Anderson (1972) and Cohn (1992) observe. But neither they nor the circumscriptional account in McCarthy and Prince (1990:227) nor the subcategorizational treatment in Inkelas (1989:248) can derive this striking phonological truth from the analysis. In particular, circumscription or subcategorization predicts that there will be complete independence between the shape of an affix and its mode of placement.

Clearly, the prosodic circumscriptional analysis of *um*-infixation in Tagalog is seriously inadequate. Nonetheless, it is correct in one respect: the locus of the infix **is** prosodically defined, since it responds to the prosodic condition requiring open syllables. The relation between this general property of prosodic theory and the locus of infixation is captured by Prince and Smolensky's (1991b, 1992, 1993) Optimality-Theoretic analysis. They propose that the locus of *–um–* is determined by the interaction of the constraint NO-CODA and the constraint EDGEMOST, which we have previously identified as a species of GA:

(42) Tagalog Constraints

a. NO-CODA

Syllables are open.

b. ALIGN-*um*

Align($[um]_{Af}$, L, Stem, L).

NO-CODA is the grammatical basis for the familiar observation about syllable markedness (Jakobson 1962:526, Clements and Keyser 1983:29). The constraint ALIGN-*um*, which is exactly equivalent to EDGEMOST ($[um]_{Af}$, L, Stem) of Prince and Smolensky (1993), says that the left edge of the affix *–um–* must coincide with the left edge of some stem; in other words, it expresses the fact that *–um–* is a prefix rather than a suffix. Violations of this constraint are reckoned gradiently in terms of distance from the designated edge, just as for ALIGN-FT in §3.

Since one of the output constraints actually determines the location of the affix *–um–* within the word, that property is not specified in the input (see §2). Thus, the input consists of e.g. $\{[um]_{Af}, [gradwet]_{Rt}\}_{Stem}$, and Gen supplies various combinations of these two elements, including combinations in which $[um]_{Af}$ lies wholly within $[gradwet]_{Rt}$.

Applied to this candidate set, the ranking relation between these two constraints leads to a pattern of phonotactic determination of the locus of infixation. The constraints are in direct conflict in any consonant-initial root, as the following tableau shows:

(43) NO-CODA >> ALIGN-*um*, from {*um, gradwet*}$_{\text{Stem}}$

Candidates	NO-CODA	ALIGN-*um*
a. [–um.grad.wet.	*** !	
b. [g–um.rad.wet.	*** !	g
c. ☞ [gr–u.mad.wet.	**	gr
d. [grad.w–u.met.	**	gradw !

The left edge of the stem is indicated by ''['', the left edge of *–um–* by ''–''. Extent of violation of the gradient constraint ALIGN-*um* is shown by the string of segments separating the left edge of *–um–* from the left edge of the stem.

The prefixed form **um–gradwet* and the post-C infixed form **g–um–radwet* respect ALIGN-*um* more than the actual output *gr–um–adwet* does, but they contain a NO-CODA violation that the others lack. This is a typical constraint conflict. Since the actual output obeys NO-CODA at the expense of an ALIGN-*um* violation, the constraints are ranked NO-CODA >> ALIGN-*um*. Violation of dominant NO-CODA therefore eliminates (43a, b) from further consideration.[14]

The remaining candidates (43c, d) are isoharmonic with respect to NO-CODA, so gradient ALIGN-*um* makes the final determination. Minimal violation of affix/stem left-alignment will lead to the affix appearing as far to the left as possible. Thus, the actual output is *gr–um–adwet*, which satisfies NO-CODA in the relevant respect and violates ALIGN-*um* minimally.

The analysis applied to *gradwet* (43) extends obviously to C-initial roots like *sulat*. The behavior of V-initial roots with respect to the constraint hierarchy is also straightforward:

[14] It might be objected that Tagalog **has** closed syllables, and so NO-CODA could not be active in the language. But in OT, the presence of closed syllables in output forms of the language merely indicates that NO-CODA is dominated, hence violated, not that it is entirely *hors de combat* — as indeed it is not. In Tagalog, NO-CODA is dominated by the faithfulness constraints PARSE and FILL (see §5 below) so input /VCCV/ is parsed faithfully as [VC.CV] in the output.

(44) *–um–* Prefixation with V-initial Roots, from {*um*, *aral*}

Candidates	NO-CODA	ALIGN-*um*
a. ☞ [–u.ma.ral.	*	Ø
b. [a.–um.ral.	** !	a
c. [a.r–u.mal.	*	ar !
d. [a.ra.–uml.	*	ara !
e. [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 NO-CODA. Two other candidates are also minimally coda-containing, so the ultimate decision is passed down the hierarchy. Since classical prefixation violates ALIGN-*um* not at all, it is manifestly more harmonic than any competitor.

In this analysis, the locus of *–um–* is determined directly by the phonology, through the phonological constraint NO-CODA. This same constraint, as part of phonological theory, is also involved in explaining the unmarkedness of open syllables (Prince and Smolensky 1993:§6). Therefore, the Optimality-Theoretic analysis provides a complete formal account of the observation that a prenuclear locus for *-um-* is consistent with the unmarkedness of open syllables.

This analysis also answers the empirical objections against the circumscriptional treatment. Because it relies on the constraint NO-CODA, rather than prosodic circumscription, it does not insist that *gr* (or worse, *adwet*) be analyzed as a prosodic constituent. And because **g–um–radwet* violates NO-CODA just as **um–gradwet* does, the analysis explains why the infix must follow the entire onset in recent loans like *gradwet*.

This approach also retains two of the virtues of the circumscriptional analysis. It continues to identify *–um–* as a prefix, rather than as some exotic and idiosyncratic morphological entity. The constraint Align(Affix, L, Stem, L) is a general form of Alignment for prefixes; its edge-reversed image Align(Affix, R, Stem, R) defines the notion *suffix*. Thus, *–um–* is a prefix, since what it means to be a prefix is to be left-aligned in the stem (*cf.* Prince and Smolensky 1991b, 1992, 1993).

The other virtue that this analysis shares with prosodic circumscription is that it conceives of the Tagalog *–um–* infixation phenomenon as a species of Prosodic Morphology. Let **P** stand for some prosodic constraint, like NO-CODA, and **M** for some morphological constraint, like Align(Affix, Stem). For morphology to be prosodic at all within OT, the ranking schema **P** >> **M** must be obeyed, in that at least **some** phonological constraint must dominate some constraint of the morphology (McCarthy and Prince 1993:§7); the scheme can also be adhered to more vigorously, with many or all phonological constraints dominating some morphological conditions. The constraint hierarchy NO-CODA >> Align($[um]_{Af}$, Stem), required in Tagalog, is an instance of Prosodic Morphology in precisely this sense. NO-CODA is obviously a prosodic constraint, therefore a member of **P**, while Align($[um]_{Af}$, Stem) is a **M** constraint, since it requires the alignment of two morphological constituents. With this ranking, the **P** constraint NO-CODA is visibly active in determining the locus of infixation, barring *–um–* from the perfectly aligned position at the left edge of the stem. (It may well be that other constraints, such as ONSET, are properly located in the **P** block here as well.)

In McCarthy and Prince (1993:§7), we propose that the ranking schema **P** >> **M** is definitional for Prosodic Morphology within OT. When a prosodic constraint dominates a morphological one, the prosodic constraint will control the outcome, as it does in Tagalog *–um–* infixation. Thus, the reversed ranking, where no **P** dominates **M**, characterizes plain or non-prosodic morphology, in which the **P**-constraints have no influence on the outcome, and only the dominant morphological constraint can have any visible effect. Thus, in ordinary peripheral affixation, the Alignment constraints imposed on ordinary prefixes and suffixes dominate all prosodic requirements like NO-CODA, leading to strict coincidence of the edge of the affix and the edge of the stem. Most other affixes in Tagalog and other languages are of course peripheral, so the Align(Affix, Stem) constraints pertaining to them are dominant, ruling out any potential prosodic effects. It is also worth noting that many affixes, by virtue of their segmental form, simply cannot be influenced by prosodic constraints to abandon strict outermost position: no harmonic gain with respect to **P** is attainable by infixal placement. For these, the relation of **P** to **M** is indeterminate.

Through the particular parametrization of GA as Align($[X]_{\text{Af}}$, Edge, Stem, Edge), we have a characterization of what it means for *X* to be a prefix or suffix, depending on the value of *Edge*. This constraint, like any other in OT, is violable in principle and violated in fact when crucially dominated. Through the ranking schema **P** >> **M** we have a characterization of how alignment of an affix with a stem edge can come to be crucially dominated: the morphological alignment constraint is dominated by a prosodic constraint. Putting these two elements together, we have a general theory of infixation: *X* is an infix only if Align($[X]_{\text{Af}}$, Stem) is crucially dominated by a constraint of the class **P**.[15] Furthermore, *X* must be shaped so as to be susceptible to prosodic influence in placement.

This theory of infixation leads to a universal typology of infixation patterns. One rather limited source of typological variation is in the setting for *Edge*, Left for infixes that have a fundamentally prefixal orientation, Right for infixes that are of the suffixal type. A richer source of interlinguistic differences lies in the identity of the active constraint in the dominant **P** system, which is keyed to the phonological composition of the affix. For Tagalog *–um–*, as we have seen, the active constraint in **P** is NO-CODA. A seemingly different pattern of infixation, observed only with reduplicative affixes, is obtained when visibly active **P** constraint is ONSET. This is exemplified below with the Austronesian language Timugon Murut. Another species of infixation emerges when **P** is itself an Alignment constraint on the interface between prosodic and morphological constituents. This pattern is also exemplified below, with the Ulwa phenomenon first introduced in §1.

In the Timugon Murut type of reduplicative infixation (45), initial onsetless syllables are skipped over. Descriptively, a light syllable (σ_{μ}) template is infixed after an initial onsetless syllable, otherwise it is prefixed.

(45) Timugon Murut Reduplicative (Prentice 1971, McCarthy and Prince 1991b, 1993:§7)

bulud	bu-bulud	‘hill/ridge’
limo	li-limo	‘five/about five’
ulampoy	u-la-lampoy	no gloss
abalan	a-ba-balan	‘bathes/often bathes’
ompodon	om-po-podon	‘flatter/always flatter’

[15] In principle, if Align($[X]_{\text{Af}}$, L, Stem, L) is crucially dominated, it is also possible that the formal **prefix** *X* will show up as a **suffix**. For this to happen, the affix *X* must be barred from infixal position either by the same phonological constraints that bar it as a prefix, or directly, by a dominant constraint demanding that the segmental constituents of morphemes be continuous (*cf.* McCarthy & Prince 1993:50, fn. 41). Two potential cases of this type are known to us, Afar (Bliese 1981, Fulmer 1990) and Huave (Noyer 1993, who investigates this phenomenon).

A circumscriptional analysis of facts like these is beset by problems. The ‘‘initial onsetless syllable’’ is not a recognized type of prosodic constituent, to fill the role of C in Φ(C, E). In general, extrametricality (that is, negative circumscription) of initial onsetless syllables doesn’t seem to be justified anywhere else in phonology or morphology (McCarthy and Prince 1993:§6, §7). Most seriously, prosodic circumscription cannot explain why all known cases (and there are many[16]) of negative circumscription of an initial onsetless syllable involve a **reduplicative** affix. The problem is that circumscription theory regards the morphological operation (in this case, prefixation of σ_μ) and the specification of the prosodic base (in this case, the residue of onsetless syllable extrametricality) as two entirely distinct matters, with no connection to one another. This means that circumscription, by its very nature, cannot account for any dependencies between them. This is the same reason that prosodic circumscription cannot relate the VC shape of Tagalog *–um–* to its prenuclear locus.

But Prosodic Morphology within OT provides a compelling non-circumscriptional account of infixation in Timugon Murut and similar cases. The key fact is that simple prefixation runs into problems with ONSET that infixation successfully avoids:

(46) ONSET (formulation from Itô 1989: 223)
*$[_\sigma$V

Reduplicating #$V_1c_1V_2$ as *#$\underline{V_1}$-.$V_1c_1V_2$ is manifestly less harmonic, syllable-wise, than reduplicating it as #V_1-$\underline{c_1V_2}$-c_1V_2, because *#$\underline{V_1}$–.$V_1c_1V_2$ duplicates an ONSET violation. Alignment of the reduplicative affix suffers, just as in Tagalog.

To apply the ranking schema **P** >> **M** to this case, we identify the decisive **P**-constraint as ONSET and the relevant **M** constraint as the version of GA which declares that the reduplicative morpheme, with its content σ_μ, is a prefix. The tableaux (47, 48) show how the correct result devolves from this ranking, assuming a set of candidates where the reduplicative affix (underscored) exactly matches the light syllable template σ_μ–:

(47) Timugon Murut σ_μ- Reduplication. C-initial Words

Candidates	ONSET	Align($[\sigma_\mu]_{Af}$, Stem)
☞ [–<u>bu</u>.bu.lud.		
[bu.–<u>lu</u>.lud.		bu !

In (47), both candidates obey ONSET, so they are passed along to Align($[\sigma_\mu]_{Af}$, Stem), which selects *<u>bu</u>–bulud*, whose prefix is perfectly prefixal.

[16] These include Sanskrit (Indo-European), Pangasinán (Philippines: Austronesian), and various non-Austronesian languages of Papua New Guinea, including Yareba, Orokaiva, and Flamingo Bay Asmat (McCarthy and Prince 1993:§7).

(48) Timugon Murut σ_μ-Reduplication. V-initial Words

Candidates	ONSET	Align($[\sigma_\mu]_{Af}$, Stem)
[–u.u.lam.poy.	** !	
☞ [u.–la.lam.poy.	*	u

But as (48) shows, there is a crucial ONSET violation in *u–ulampoy* that is absent in *u–la–lampoy*. Since ONSET is ranked higher, it alone determines the outcome, though Align($[\sigma_\mu]_{Af}$, Stem) would give the opposite result.[17]

Remarkably, in the body of data we have studied, only **reduplicative** infixes are found in this particular locus, never ordinary, segmental infixes. The proposal here explains why, sharply distinguishing it from accounts based on negative prosodic circumscription. The core of the explanation is apparent: copying the initial onsetless syllable of *ulampoy* duplicates the ONSET violation. No comparable pressure exists for contentful infixes, regardless of their shape, since they of course cannot duplicate a violation of ONSET. This result submits to formal proof, given in McCarthy and Prince (1993:§7).[18] The **P** >> **M** schema thus yields a theory of infixability, predicting both what kind of morpheme-shapes can be infixed at all and where they can lodge in their hosts.

As in Tagalog, phonotactic well-formedness, rather than prosodic circumscription, is responsible for infixation. This follows from the Prosodic-Morphological ranking schema **P** >> **M**. Indeed, we can go even further and observe that the Timugon Murut grammatical system need not be merely **analogous** to Tagalog's, but may well be actually **identical** to it. Both grammars can contain the constraint hierarchy {ONSET, NO-CODA} >> Align(Af, Stem), where Af is *um* in Tagalog, σ_μ in Timugon Murut. The only difference between the two cases is in which of the prosodic constraints does the actual work of compelling infixation. But this difference is entirely superficial: it follows from the different lexical substance of the two morphemes, since Tagalog *um* has a potential coda (and lacks an onset) while σ_μ cannot contain a coda in any case. Because of this, including both prosodic constraints in the hierarchy has no effect on the outcome, as the following tableaux certify:

[17] A further logical possibility is *u.lu.lam.poy*, which fares no worse, ONSET-wise, than the actual output, and which violates Align($[\sigma_\mu]_{Af}$, Stem) not at all. Nonetheless, this form is non-optimal, because it directly contravenes the light-syllable requirement imposed by the reduplicative affix σ_μ–. The reduplicated string, underscored in *u.lu.lam.poy*, consists of a heterosyllabic V.C sequence, in blatant disregard of the shape requirement expressed by the reduplicative template.

[18] Cheryl Zoll notes that the hypothetical constraint NO-HIATUS, which prohibits only **medial** onsetless syllables, can produce the post-initial-onsetless syllable pattern with a segmental infix. By this constraint, the hiatus of hypothetical ***ta****ulampoy* is inferior to *u**ta**lampoy*, which violates ONSET but not NO-HIATUS. It is therefore important that we argue, below in §5 and in McCarthy and Prince (1993:§4), that there is no such constraint as NO-HIATUS, its effects being obtained from a combination of ONSET and an Alignment constraint.

(49) ONSET, NO-CODA >> ALIGN-*um*, in Tagalog

Candidates	NO-CODA	ONSET	ALIGN-*um*
a. [–um.grad.wet.	*** !	*	
b. [g–um.rad.wet.]	*** !		g
c. ☞ [gr–u.mad.wet.	**		gr
d. ☞ [–u.ma.ral.	*	*	
e. [a.r–u.mal.	*	*	ar !

(50) ONSET, NO-CODA >> Align(σ_μ, Stem), in Timugon Murut

Candidates	NO-CODA	ONSET	Align($[\sigma_\mu]_{Af}$, Stem)
a. ☞ [–.bu.bu.lud.			
b. [.bu.–bu.lud.			bu !
c. [–.u.u.lam.poy.		** !	
d. ☞ [.u.–la.lam.poy.		*	u

Including ONSET in the set of dominant **P**-constraints in Tagalog and NO-CODA in the set in Timugon Murut does not change the result. Thus, if **P** is as inclusive as possible, the grammars of the two languages are truly identical.

A final example of direct prosodic conditioning of infixation. There is a near mirror-image of the Timugon Murut pattern, in which a reduplicative suffix follows a word-final vowel (V+Af#) but is infixed before a word-final consonant (Af+C#). A case of this sort is Kamaiurá (Everett and Seki 1985, who however offer a different analysis):

(51) Kamaiurá Infixing Reduplication

o–huka	ohuka–huka	‘he laughed/kept laughing’
o-mo–tumuŋ	omotumu–tumu–ŋ	‘he shook it/repeatedly’
je–umirik	jeumiri–miri–k	‘I tie up/repeatedly’
o–je–ʔapah^{w}at	ojeʔapah^{w}a–pah^{w}a–t	‘he rolls himself up/repeatedly’
o–etun	oetu–etu–n	‘he smells/keeps on smelling’
a–pot	apo–apo–t	‘I jump/repeatedly’
o–ekɨj	oekɨ–ekɨ–j	‘he pulls/repeatedly’

In Kamaiurá, the reduplicative affix is a disyllabic foot-template. It is a formal suffix, therefore subject to Align($[Ft]_{Af}$, R, Stem, R). Under the Prosodic Morphological ranking schema **P** >> **M**, this **M**-constraint is dominated by the **P**-constraint NO-CODA, yielding the observed distribution of the Kamaiurá reduplicative infix. Here again, there can be no segmental infix with this distribution.[19]

In the cases of infixation discussed thus far, the responsible **P**-constraint is ONSET or NO-CODA, the two fundamental constraints in universal syllable structure theory (Prince and Smolensky 1993:§6). Other patterns of infixation can be obtained when the dominant, visibly active **P**-constraint is a species of Alignment. Specifically, we shall be concerned here (and subsequently) with Alignment constraints on the **interface** between prosody and morphology, requiring the coincidence of edges of prosodic constituents with morphological ones.

The case of Ulwa, first introduced in §1, is one example of this type. (Ulwa, a language of the Atlantic coast of Nicaragua, is analyzed by Hale and Lacayo Blanco (1989) and was brought to our attention by Bromberger and Halle 1988.) The possessive in Ulwa is marked by a set of infixes located after the first or second syllable of the noun:[20]

(52) Ulwa Possessive Forms

su:lu	‘dog’
su:–ki–lu	‘my dog’
su:–ma–lu	‘thy dog’
su:–ka–lu	‘his/her dog’
su:–ni–lu	‘our (incl.) dog’
su:–kina–lu	‘our (excl.) dog’
su:–mana–lu	‘your dog’
su:–kana–lu	‘their dog’

The generalization is that the possessive infix follows a heavy initial syllable (all monosyllabic words are heavy), and otherwise it follows the second syllable. This initial string, preceding the infix, is identical to the main-stress foot of the language.

[19] For a formal proof of this result, see McCarthy and Prince (1993:§7).

[20] POSS itself appears to be composite, consisting of the sequence Person+Number. When we refer to the ‘‘possessive morpheme,’’ we mean the whole unit.

(53) Location of Ulwa Infixes (noun + ‘his’)

a. After Initial Syllable

bas	bas–ka	‘hair’
ki:	ki:–ka	‘stone’
su:lu	su:–ka–lu	‘dog’
asna	as–ka–na	‘clothes’

b. After Peninitial Syllable

sana	sana–ka	‘deer’
amak	amak–ka	‘bee’
sapa:	sapa:–ka	‘forehead’
siwanak	siwa–ka–nak	‘root’
kululuk	kulu–ka–luk	‘woodpecker’
ana:la:ka	ana:–ka–la:ka	‘chin’
arakbus	arak–ka–bus	‘gun’
karasmak	karas–ka–mak	‘knee’

The Ulwa phenomenon has been analyzed as **positive prosodic circumscription** (McCarthy and Prince 1990: 225-243; *cf.* Broselow and McCarthy 1983, Aronoff 1988). In these terms, the possessive infixes are actually suffixes on a prosodically delimited base, the initial foot. Formally, the morphology of the Ulwa possessive is specified by O:Φ(Ft, L), where O is the morphological operation ‘‘Suffix *ka*, *ki*, *ma*, etc.’’ and Φ(Ft, L) is a function that returns the leftmost foot of the word. As (54) shows schematically, the Φ-delimited portion of the word serves as the base to which suffixation of *–ka–* applies:

(54) Prosodic Circumscription in Ulwa Possessive (McCarthy and Prince 1990a)

Input	(siwá)nak
Circumscriptional Analysis	siwá * nak
Suffix *ka* under PC	siwá–ka * nak
Output	siwákanak

In (54), the underscoring marks the kernel, the Φ-delimited substructure of the base. Parentheses indicate foot structure.

Like negative prosodic circumscription, positive prosodic circumscription is framed in terms of operations on forms: delimit the prosodic base and suffix morpheme X. In contrast, the idea in OT is that constraints evaluate output forms and have nothing to say about the operations that build them. In essence, circumscription provides a way of controlling the **input** to morphological and phonological **operations**, but OT only wants a way to evaluate the **output structures**.

We have this in hand, through GA. The sought-for configuration in Ulwa is one in which the **left** edge of *–ka–* and the other possessive morphemes coincides with the **right** edge of the main-stress foot:

(55) ALIGN-TO-FOOT (Ulwa)

Align($[\text{POSS}]_{\text{Af}}$, L, Ft′, R)

The expression Ft′ stands for the head foot of the PrWd, H(PrWd).[21] Thus, the left edge of *–ka–*, indicated by ‘‘–’’, must coincide with the right edge of the head Ft, indicated by ‘‘)’’, as in the following examples:

[21] McCarthy and Prince (1993:§7) propose a somewhat different account in terms of the Alignment-related notion **Base**.

(56) ALIGN-TO-FOOT, Applied

(bas)–ka		Root = Ft.
(amak)–ka		"
(sana)–ka		"
(su:)-ka–lu	*(su:)lu–ka	Not aligned with Ft.
(siwa:)–ka–nak	*(siwa:)(nak)–ka	Not aligned with head Ft.
(ana:)–ka–la:ka	*(ana:)(la:)ka-ka	Not aligned with Ft.

To satisfy ALIGN-TO-FOOT, the locus in which *–ka–* appears must be the head foot. The forms in the middle, in which *–ka–* is wrongly suffixed rather than infixed, all fail this requirement. ALIGN-TO-FOOT can be thought of as a particularly aggressive type of **prosodic subcategorization**, defined in terms of the edge of the affix and the edge of a prosodic constituent. Prosodic subcategorization is first proposed as an account of Ulwa-type infixation in Broselow and McCarthy (1983:53-68); it is extended to other types of infixation and related phenomena in Inkelas (1989) and Booij and Lieber (to appear).

The ALIGN-TO-FOOT constraint (55) requires the coincidence of edges of a morphological constituent with a prosodic one. Any instance of the category 'POSS', *–ka–* included of course, must have its left edge coincide with the right edge of the head foot. But the possessive morphemes of Ulwa are also formal suffixes, as one important empirical consideration shows. In about 10% of the nouns collected by Hale and Lacayo Blanco (1989), *–ka–* is an actual suffix on a word that is longer than a single iambic foot:

(57) Suffixed *–ka–*

gobament-ka	'government'
abana-ka	'dance'
bassirih-ka	'falcon'
ispiriŋ-ka	'elbow'

Of these, about ⅔ have doublets where *ka* is infixed as expected: *bas–ka–sirih*, *is–ka–piriŋ*. The exceptional forms show that *ka* is a formal suffix. This indicates that it is also subject, like all suffixes, to the form of GA in (58).

(58) ALIGN-IN-STEM

Align($[\text{POSS}]_{\text{Af}}$, R, Stem, R)

In accordance with the **P** >> **M** ranking schema, when morphology is prosodic, a prosodic constraint must dominate a morphological one. In the great majority of the Ulwa vocabulary, the distribution of 'POSS' **is** prosodically determined, so the **P** constraint ALIGN-TO-FOOT dominates the **M** constraint ALIGN-IN-STEM:

(59) ALIGN-TO-FOOT >> ALIGN-IN-STEM, from {*ka*, *siwanak*}

Candidates	ALIGN-TO-FOOT	ALIGN-IN-STEM
a. (siwa)nak–ka	* !	
b. ☞ (siwa)–ka–nak		*

In an exceptional subset of Ulwa nouns, though, the distribution of 'POSS' is purely morphologically determined, so in that portion of the vocabulary, the opposite constraint ranking must obtain:

(60) Exceptional ALIGN-IN-STEM >> ALIGN-TO-FOOT, from {*ka*, *gobament*}

Candidates	ALIGN-IN-STEM	ALIGN-TO-FOOT
a. ☞ (goba)ment–ka		*
b. (goba)–ka–ment	* !	

The doublets allow either ranking. Each constraint masks the other completely when dominant; we only see that both are active from the lexically-determined ranking reversal.

This analysis illustrates a general approach to infixation via positive prosodic circumscription within OT. On the one hand there is a **P**-constraint defining the locus of affixation prosodically. It is a constraint on the prosody/morphology interface, demanding that the affix be preceded or followed by a phonological string of a particular type. On the other hand there is an **M**-constraint, Align(Af, Stem), that characterizes normal suffixing or prefixing behavior. Whenever affixation is prosodically determined, the interaction between these two competing requirements is set by **P** >> **M**.

Another infixing situation where the dominant **P** constraint requires Alignment of prosodic and morphological constituents is the Siouan language Dakota. A further refinement in this case is that the purely prosodic constraint ONSET is also dominant, yielding a mixed system with a complex infix/prefix alternation. The source of most data and descriptive generalizations cited here is Moravcsik (1977:93-108).[22]

The Dakota agreement system consists of a set of perhaps twenty person/number affixes. They are prefixed to monosyllabic verb roots and some polysyllabic ones, but they are infixed into other polysyllabic verb roots of a lexically specified subclass. (The infix-taking polysyllables may have been composite in the past.) The locus of infixation is after the initial syllable, which is always open in Dakota (Shaw 1980):

(61) Infixation of *–wa–* 'I' in Dakota

pa–wa–ȟta	'I tie up'
ma–wa–ni	'I walk'
ma–wa–nų	'I steal'
ċa–wa–pa	'I stab'
'i–ma–ktomi	'I am Iktomi'
na–wa–pca	'I swallow it'
na–wa–t'aka	'I lock the door'
la–ma–k'ota	'I am a Lakota'

The agreement morphemes of Dakota are formally prefixes, so they fall under ALIGN-IN-STEM:

[22] Moravcsik details various additional intricacies, some of which are discussed in McCarthy and Prince (1993:§7). Examples are cited directly from Moravcsik, and they preserve the dialectal and transcriptional idiosyncrasies of her sources.

(62) ALIGN-IN-STEM (Dakota)
Align($[AGR]_{Af}$, L, Stem, L)

For the infix-taking subclass of verb roots, however, the agreement morphemes are barred from initial position by the dominant interface constraint ALIGN-ROOT:

(63) ALIGN-ROOT (Dakota)
Align(Root, L, PrWd, L)

This constraint requires that the PrWd begin neatly on the edge of a root, effectively banning true prefixes. In the infix-taking class of roots, the relation between these two constraints is set by the Prosodic Morphological ranking schema **P** >> **M**, so the prosody/morphology interface constraint ALIGN-ROOT dominates the purely morphological constraint ALIGN-IN-STEM.

This interaction between ALIGN-ROOT and ALIGN-IN-STEM forces the agreement morphemes out of absolute initial position, but the minimally-infixing candidate is incorrect: **ċ**wa**.a.pa*, for example, obeys ALIGN-ROOT and minimally violates ALIGN-IN-STEM, yet it is non-optimal. Another constraint is involved, and as the syllabification in **.ċ**wa**.a.pa.* suggests, it is the **P**-constraint ONSET.[23]

[23] According to Boas and Deloria (1941:4), all empty onsets in surface forms are filled by *ʔ*. For the current argument, we assume that epenthesis of *ʔ* is a separate matter, outside the level at which the locus of infixation is determined. If this should turn out to be incorrect, then it is a straightforward matter to re-cast the argument using the **P**-constraint FILL (*v.* §5 below) rather than ONSET, so the crucially non-optimal candidate is instead FILL-violating **.ċ–wa–.□a.pa.*

The following tableau shows that, like ALIGN-ROOT, ONSET must dominate ALIGN-IN-STEM:

(64) **P** >> **M**, from {*wa, ċapa*}

Candidates	**P**		**M**
	ONSET	ALIGN-ROOT	ALIGN-IN-STEM
a. [–wa.|ċa.pa.		* !	
b. [|ċ–wa.a.pa.	* !		ċ
c. ☞ [|ċa.–wa.pa.			ċa

The interesting edges are all shown: the left edge of the root is denoted by ‘‘|’’, the left edge of the affix by ‘‘–’’, and the left edge of PrWd by ‘‘[’’. Example (64a) violates ALIGN-ROOT, because the left edge of the root is PrWd-internal. Example (64b) has an obvious ONSET violation. Because both of the **P** constraints ONSET and ALIGN-ROOT are dominant, the affix *–wa–* must fall after the initial syllable, as in (64c). Candidates in which the affix migrates even further to the right, such as **ċa.pa.–wa* or **lak‘o–ma–ta*, perform equally well on the dominant constraints, but only (64c) also involves minimal violation of ALIGN-IN-STEM (*cf.* (43c, d)),[24] rendering the morpheme *–wa* optimally prefixal.

This system yields the correct post-first-syllable locus for consonant-initial affixes. It turns out, however, that there is a special set of phonological conditions under which roots that are in the infixing class take **prefixed** agreement instead. The affix involved is V-initial, the second person dual, which is *ųk* before vowels and *ų* before consonants.[25] It is the only VC-shaped agreement morpheme in Dakota. The root showing this pattern must also be V-initial. Here are some examples, using the roots *manu* ‘steal’ and *ali* ‘climb’:[26]

(65) Patterning of Root Type and Infix Type in Dakota

	CV affix /wa/ ‘1sg.’	***VC affix*** /ų(k)/ ‘1du.’
[C root manų	ma–wa–nų	ma–ų–nų
[V root ali	a–wa–li	ųk–ali

The double-boxed example on the lower right is the case of interest. In it, the unique VC agreement morpheme of Dakota is *prefixed* to a V-initial root. Naively, we would have expected **a–ų–li* instead.

[24] Another logical possibility is *[–*wa*[|*ċapa*]], in which ALIGN-ROOT is satisfied by positing a recursive instance of PrWd. This must be ruled out by some dominant constraint, either a general prohibition on PrWd recursion, or perhaps a specific prohibition on Alignment of the right edge of *–wa–* with the left edge of PrWd.

[25] This allomorphy is obviously ONSET-governed; see Mester (to appear) for relevant discussion.

[26] The examples in (65) have been cited from or constructed on the basis of the description in Boas and Deloria (1941:78f.).

But ONSET has something to say about the matter. ONSET crucially dominates ALIGN-ROOT, as the following tableau demonstrates:

(66) ONSET >> ALIGN-ROOT, from {*ų(k), ali*}

Candidates	ONSET	ALIGN-ROOT	ALIGN-IN-STEM
a. ☞ [–ų.k|a.li.	*	*	
b. [|a.–ų.li.	** !		a

ALIGN-IN-STEM would also correctly distinguish the two candidates, but it cannot, because it is crucially ranked below ALIGN-ROOT. (The ranking argument is in (64).) The optimal candidate ⋆*ų.ka.li* contains a single ONSET violation (marked by the symbol ⋆), but the competitor contains two: *⋆*a–.⋆ų–li*. Because ONSET dominates ALIGN-ROOT, the prefixed candidate, with minimal ONSET violation, is selected as the output. Observe the contrast with the case of *ma–ų–nų* listed in (65). Here the candidates *⋆*ų–manų* and **ma–⋆ų–nų* are tied on ONSET, violating it equally; so the decision is thrown to ALIGN-ROOT. In this way, two **P**-constraints, one purely phonological and the other pertaining to the morphology-prosody interface, yield the complex, partly infixal, partly prefixal distribution of Dakota agreement affixes. (Non-optimal candidates of another type, such as **m–ųk–anų* or **al–ųk–i*, show that a full analysis will also require a constraint enforcing integrity of root syllables. This constraint is also applicable to (64b) and to the /VCV/ infix *–iċi–* (*v.* McCarthy and Prince 1993:124n.).)

In sum, what we have here is a comprehensive theory of infixation based on OT. Two fundamental ideas underlie this approach. One, due to Prince and Smolensky (1991b, 1992, 1993), is that the status of an affix as prefix or suffix is a formal, therefore violable constraint. Here we have identified this constraint as a species of GA, Align(Af, Stem). The other, developed in McCarthy and Prince (1993:§7), is that prosodic-morphological phenomena emerge from the constraint ranking schema **P** >> **M**, where **P** is a prosodic constraint and **M** is a morphological one. For infixation, the relevant **M**-constraint is just exactly Align(Af, Stem), and it is crucially dominated by one of the **P**-constraints in (67).

(67) Decisive Dominant **P**-Constraints in Infixation
- a. Pure Prosodic Constraints
  - i. ONSET
    - Timugon Murut
    - Dakota
  - ii. NO-CODA
    - Tagalog
    - Kamaiurá
- b. Alignment Constraints on Interface: Align(GCat, PCat)
  - i. ALIGN-TO-FOOT: Align(Af, Edge1, PCat, Edge2), Edge1 ≠ Edge2
    - Ulwa
  - ii. ALIGN-ROOT: Align(Root, Edge1, PrWd, Edge2), Edge1 = Edge2
    - Dakota

These are the cases described above; additional examples can be found in McCarthy and Prince (1993:§7).

By dominating the morphological constraint Align(Af, Stem), the phonological constraints in (67) compel non-peripheral placement of the affix. The constraints may be purely prosodic — the basic principles of syllable structure ONSET and NO-CODA — or they may be Alignment constraints themselves. In principle, two kinds of Alignment should be able to force non-peripheral affixation, and both are actually attested. If a particular affix ''subcategorizes'' for a prosodic constituent, it will optimally align with an edge of that prosodic constituent. And if an edge of the root should be required to coincide with an edge of PrWd, then affixation at that edge will be non-harmonic. These **P**-constraints correspond to two instantiations of GA, the subcategorizing Align(Af, Edge1, PCat, Edge2), and the root-aligning Align(Root, PrWd). Thus, Alignment theory figures in the characterization of infixation in two respects: it supplies the stem-edge alignment constraints that describe ordinary peripheral affixation, crucially violated in infixation; and for cases like (67b), it provides the interface constraints that compel non-peripheral affixation when dominant.

§5. Generalized Alignment and the Prosody-Morphology Interface

The interface constraints we have just examined are of the general form Align(GCat, Edge, PCat, Edge); they require that the edge of any instance of the **morphological** constituent GCat align with the corresponding edge of some **prosodic** constituent PCat. For example, ALIGN-ROOT (63) in Dakota requires that the left edge of the root coincide with the left edge of the PrWd, leading to an infixed locus for formal prefixes. But similar Alignment constraints on the morphology-prosody interface can have effects other than infixation when embedded in different systems of interacting constraints. In this section, we will show that Align(GCat, Edge, PCat, Edge) can have profound consequences for the prosody of a language in relation to its morphology. We will focus specifically on the following two constraints of this type:

(68) ALIGN-LEFT
Align(Stem, L, PrWd, L)

(69) ALIGN-RIGHT
Align(Stem, R, σ, R)

These constraints demand, respectively, that every stem begin at the left edge of a PrWd and that it end at the right edge of a syllable.[27] Phenomena variously attributable to the cycle, to domains of rule application, and to extrametricality can all be subsumed under this rubric, within OT.

Many of the consequences of ALIGN-LEFT and ALIGN-RIGHT for prosody and especially segmental phonology derive ultimately from a property of Gen dubbed Consistency of Exponence above in §2 (*v.* also McCarthy and Prince 1993:§2). This condition places a fundamental limit on Gen's freedom to hypothesize output candidates: it cannot alter the grammatical analysis of the input. The input consists of various morphemes, root or affix, arranged into stems. The input also includes the lexical specifications of the phonological segments making up its constituent morphemes. Gen takes this input and, respecting Containment, posits various candidate output forms. Under Consistency of Exponence, the affiliations of segments with particular morphemes cannot change in the output, nor can segments be added to or subtracted from a morpheme.

This is, however, not to say that all and only the segments of the input are actually pronounced; what is actually pronounced is determined by the prosody of the optimal output form. Epenthesis and

[27] The asymmetry between PrWd-demanding ALIGN-LEFT and σ-demanding ALIGN-RIGHT deserves scrutiny. We return to the matter (p. 56), after exploring the empirical sense of the constraints as formulated.

deletion phenomena are simply special situations in prosodic parsing. For epenthesis, the syllable parse posits segmentally unfilled structural positions, which receive a default interpretation as some actual segment, such as *a* or *i*, *t* or *ʔ* (Selkirk 1981, Archangeli 1984, Itô 1986, 1989). For deletion, the syllable parse is incomplete, leaving some segments crucially unparsed, to be ignored in the subsequent interpretation (McCarthy 1979, Steriade 1982, Itô 1986, 1989). Unfilled structural positions in candidate output forms are indicated by □, and unparsed segments are bracketed with ''⟨…⟩''. Gen supplies output candidates with various combinations of unfilled and unparsed elements, and their distribution in actual languages is controlled by the following two fundamental constraints (Prince and Smolensky 1991a, 1991b, 1992, 1993), which for present purposes can be stated like this:

(70) PARSE
⟨α⟩ is prohibited.

(71) FILL
□ is prohibited.

The ranking of PARSE and FILL relative to each other and to the constraints on syllable well-formedness like ONSET and NO-CODA characterizes the basic syllabic typology of the world's languages (Prince and Smolensky 1993:§6).[28]

With this much technical development in hand, we can see how two important Alignment effects come to affect the assignment of syllable structure. In Axininca Campa, an Arawakan language of Peru,[29] hiatus at /V+V/ juncture is prohibited. Potential hiatus leads to surface consonant epenthesis, shown by the element □ (interpreted as *t*) in (72).

(72) Epenthetic Examples in Axininca Campa

/i-N-koma–i/	iŋ.ko.ma.□i	'he will paddle'
/i-N-koma–aa–i/	iŋ.ko.ma.□aa.□i	'he will paddle again'
/i-N-koma–ako–i/	iŋ.ko.ma.□a.ko.□i	'he will paddle for'
/i-N-koma–ako–aa–i–ro/	iŋ.ko.ma.□a.ko.□aa.□i.ro	'he will paddle for it again'
/i-N-čʰik–i/	iñ.čʰi.ki	'he will cut'
/i-N-čʰik–aa–i/	iñ.čʰi.kaa.□i	'he will cut again'
/i-N-čʰik–ako–i/	iñ.čʰi.ka.ko.□i	'he will cut for'
/i-N-čʰik-ako–aa–i–ro/	iñ.čʰi.ka.ko.□aa.□i.ro	'he will cut for it again'

The constraint implicated here is obviously ONSET. When morphemic combination brings together /V+V/, the heterosyllabic parse [V.V] produces an onsetless syllable. All such faithfully-parsed candidates are sub-optimal; competing with them are **unfaithful** candidate forms, which satisfy ONSET by positing

[28] FILL and PARSE are each representatives of families of constraints, where the specific instance of the constraint is determined by which node is taken as the focus of evaluation. PARSE demands that the node be properly mothered (PARSE-SEG, that segments be syllabified; PARSE-SYLL, that syllables be footed; and so on), and FILL demands that it dominate its proper child. FILL militates against *empty* structure, and thus belongs to a family of constraints that militate against all kinds of structure, of which the most general is the virtually Manichean *STRUC: avoid structure altogether.

[29] Axininca Campa is the subject of a comprehensive analysis by Payne (1981), from which most of our data come. (Some additional forms are taken from Spring (1990).) The discussion here is drawn from a near-complete Optimality-Theoretic account of Axininca Campa prosody and prosodic morphology in McCarthy and Prince (1993).

FILL violation (that is, the empty consonant □ in (72)) or unparsed segments. Of these, PARSE violators — with phonetic loss of one or the other of the V's — are never found. Thus, PARSE, is undominated and so unviolated. FILL-violation is the pattern seen in (72).

The appearance of □ satisfies the requirement that syllables have onsets. This means that ONSET dominates FILL in the constraint ranking, as the following tableau shows:

(73) ONSET >> FILL, from /iN-koma-i/

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

The comparison between candidates here shows that FILL conflicts with ONSET. Since performance on ONSET is decisive, and FILL violation or satisfaction is irrelevant, we conclude that ONSET >> FILL.

Tableau (73) establishes the ranking of ONSET and FILL, but it is not a complete account of the optimality of candidates like *iŋ.ko.ma.□i*. Two problems remain. First, tableau (73) completely disregards the **initial** violation of ONSET in *iŋ.ko.ma.□i*; surely **□iŋ.ko.ma.□i*. should be more harmonic, since it contains no violations of ONSET at all. Second, because *ai* is a permissible diphthong of Axininca Campa, it is logically 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 output should beat FILL-violating *iŋ.ko.ma.□i*.

We record these two observations as follows:

(74) Initial V

Axininca Campa has no word-initial epenthesis and freely tolerates initial onsetless syllables.

(75) Non-coalescence of /V+V/

Underlying /V–V/ sequences at stem-suffix juncture are never parsed as tautosyllabic; they always correspond to V.□V in the output.

The first observation bans epenthesis; the second requires it. Nevertheless, both observations devolve from conditions on GA, requiring coincidence of the edges of prosodic and morphological constituents.

We begin with the Initial V phenomenon. Axininca surface structures are replete with vowel-initial words, in flagrant violation of ONSET. This mode of departure from strict ONSET obedience is common in other languages as well, so it is no mere fluke of Axininca Campa. As a bare-faced fact, this observation would seem to require parametrizing ONSET, to exclude PrWd-initial syllables from its purview:

(76) ''NO-HIATUS'' (Hypothetical Constraint, Parametrizing ONSET)

*$[_{\sigma}$V **except word-initially**.

The codicil is specifically crafted so that ''NO-HIATUS'' cannot compel FILL-violation in initial position. This will eliminate initial epenthesis.

Parametrizing ONSET by adding ''NO-HIATUS'' to the panoply of universal constraints is obviously unsatisfactory. It does not explain why just exactly word-initial position is special, and it compromises the claim of OT that languages differ principally in how they rank a fixed set of universal constraints. It would be far better to retain the original, simple version of ONSET, without parametrization via ''NO-HIATUS'', as the only possibility permitted by phonological theory.

Another approach to the Initial-V phenomenon, this time a more familiar one, is to say that initial onsetless syllables are extrametrical, therefore outside the purview of ONSET. This is the tack taken by Spring (1990:37-44) and Black (1991). It has both local and global problems. Within Axininca Campa grammar, there is no other good evidence that initial onsetless syllables are extrametrical, and there is much evidence, from word minimality, stress, allomorphy, and reduplication, showing that they are actually **intra**metrical (McCarthy and Prince 1993:§6). We return to the broader issue of extrametricality below, in the discussion of example (97).

Rejecting these alternatives, we propose that the Initial-V phenomenon arises from the interaction of ONSET and ALIGN-LEFT (68), which says that the left edge of any stem must coincide with the left edge of a PrWd. ALIGN-LEFT is unviolated and therefore undominated in the constraint hierarchy of Axininca Campa. ONSET is violated when it conflicts with ALIGN-LEFT; therefore ONSET cannot dominate ALIGN-LEFT. This gives us ALIGN-LEFT >> ONSET. The effects on initial C-epenthesis are shown in (77), where the symbol ''|'' marks the relevant GCat-edge (here, $[_{Stem}$) and the PrWd-edge is shown by ''['':

(77) Failure of Prothesis, from /i–N–koma–i/

Candidates	ALIGN-LEFT	ONSET	FILL
a. [.|iŋ.ko.ma.i.		** !	
b. ☞ [.|iŋ.ko.ma.□i.		*	*
c. [.□|iŋ.ko.ma.□i.	* !		**

The initial □ in the losing candidate (77c) shifts the PrWd-edge away from the stem-edge, causing misalignment of the leading edges of the PrWd and the stem. This means that all V-initial stems of Axininca must be parsed with an ONSET violation, to satisfy dominant ALIGN-LEFT. In contrast, both (77a) and (77b) are well-aligned, but the former contains multiple ONSET violations, in contravention of the Optimality-Theoretic imperative of minimal violation.

The application of ALIGN-LEFT in this example relies crucially on Consistency of Exponence, as explicated above. Specifically, the epenthetic element □ is part of the prosodic constituent PrWd, but it 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. Gen is denied the power to add elements like □ to a morpheme — indeed to add anything at all to a morpheme — so the segmental composition of root, affix, or stem is the same in the output as in the input. Thus, epenthetic elements have no morphological affiliation whatsoever. In this way, satisfaction of ALIGN-LEFT demands a faithful parse at the left edge of the stem, as in (77a, b); in (77c) the element □ at the left edge of PrWd, belonging to PrWd but not to stem, is sufficient to de-align the PrWd and stem edges.

An alternative to FILL-violation is PARSE-violation, leading to non-pronunciation of initial vowels. This alternative fares no better in the face of undominated ALIGN-LEFT, however, since an unparsed segment is still a part of the morpheme (and hence the stem) that sponsors it:

(78) De-Alignment by Unparsed Initial Syllable

* |⟨iŋ⟩[koma□i

Underparsing can never bring a form into agreement with ALIGN-LEFT. For ALIGN-LEFT to be satisfied, the stem-initial segment, vowel or consonant, must occupy initial position in a PrWd. Consequently, an unparsed initial vowel, which occupies no position at all in any syllable, will de-align a stem.

Word-initial ONSET-violation could also be avoided by trans-junctural syllabification, parsing the final consonant of one word as the onset of the following word. Again, unviolated ALIGN-LEFT excludes this possibility, as the following schema shows:

(79) De-Aligning Trans-Junctural Syllabification

/matan iŋkomai/	→	* mata[.n|iŋkoma□i
		* mata.n|iŋ[koma□i

The example is purely hypothetical, since Axininca Campa, with a strict constraint on possible codas (82), does not permit any word-final consonants whatsoever. Still, this effect of ALIGN-LEFT is real, and it is important in other languages discussed below.

In sum, ALIGN-LEFT explains why word-initial position should be an apparent exception to ONSET in terms of constraint interaction and the general theory of the prosody/morphology interface. Moreover, ALIGN-LEFT makes predictions beyond allowing initial onsetless syllables: it forbids all 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 it is equally important in the grammar of augmentation to bimoraicity (*v.* below (89)). For purely empirical reasons, then, it's correct to reject NO-HIATUS and preserve the pristine constraint ONSET, abetted by ALIGN-LEFT.

The Axininca data in (72) also exhibit another phenomenon, Non-Coalescence of /V+V/. A further constraint is required, ALIGN-RIGHT (69). It must dominate FILL, because it compels FILL-violation. Observe how, in the following examples, epenthesis guarantees alignment of the end of the stem and the end of a syllable, whereas coalescence places the morphological stem-edge internal to a syllable:[30]

(80) Stem-Syllable Alignment

a. /iN-koma–i/	.iŋ.ko.ma.|□i.
	*.iŋ.ko.ma|i.
b. /iN-koma–ako–i/	.iŋ.ko.ma.|□a.ko.|□i.
	*.iŋ.ko.ma|a.k.o|i.

Each suffix is assumed to create a new stem category recursively, and the right edge of each such stem lies at a syllable boundary, in accordance with ALIGN-RIGHT. It is crucial, of course, that ALIGN-RIGHT quantify universally over stems, but existentially over syllables, in accordance with the definition of GA in (4). Thus, ALIGN-RIGHT does **not** demand that every syllable-edge coincide with a stem-edge (which would say that roots and affixes must be monosyllabic).

[30] Yip (1983:244-5) proposes 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 by repeating an ALIGN-like restriction in the contexts of two separate epenthesis rules.

As noted, ALIGN-RIGHT is ranked above FILL, forcing the appearance of empty structure even where a faithful, non-epenthetic parse would meet the purely phonological requirements on Axininca syllables. The following tableau makes this clear:

(81) ALIGN-RIGHT >> FILL, from /iN-koma-i/

Candidates	ALIGN-RIGHT	FILL
a. ☞ .iŋ.ko.ma|.□i.		*
b. .iŋ.ko.ma|i.	* !	

With this ranking, failure to meet ALIGN-RIGHT dooms the coalescent form.

These facts have been regarded previously as evidence of **cyclic** syllabification (Spring 1990:52-53, 161-162; Black 1991:205). The idea is that a syllable formed on one cycle is closed to the addition of further segments on later cycles. For example, in *iŋkoma□i*, the cyclic domain *iŋ.ko.ma* is fully syllabified as shown. When the suffix *i* is added on the next cycle, it cannot be joined to the syllable *ma*, which is now closed to the addition of further segments.

The cyclic analysis encounters various difficulties. For one thing, the failure of coalescence at morpheme juncture is the only evidence for cyclic rule application in the language.[31] For another, the specific details of the account are not compatible with any general theory of the cycle to be found in the literature. Steriade (1988:309-10) 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 would have to be cyclic domains, since they show closure just like affixes. Thus, cyclic syllabification in Axininca would be very much an isolated peculiarity, both within the language and within linguistic theory as a whole.

ALIGN-RIGHT is a dominated constraint, so it is violated elsewhere in the language. The circumstance where this is most obvious is /C+V/ juncture, as in /i–N–č^{h}ik–i/ → *iñ.č^{h}i.ki* (72). The dominant constraint here is a ''coda condition'', to use Itô's (1986) term, which bars *k* (and most other consonants) from syllable-final position. We state it informally here:

(82) CODA-COND (Axininca Campa)

A coda consonant can only be a nasal homorganic to following stop or affricate.

The following ranking argument establishes this result:

[31] Another potential case, involving the phonology of the velar glide, is discussed in McCarthy and Prince (1993:§A.3).

(83) CODA-COND >> ALIGN-RIGHT, from /iñ-čʰik-i/

Candidates	CODA-COND	ALIGN-RIGHT
a. ☞ .iñ.čʰi.k|i.		*
b. .iñ.čʰik|.□i.	* !	

The failed candidate in (83) is a FILL-violator too, but irrelevantly, since FILL is ranked below ALIGN-RIGHT, as (81) shows. Other possible candidate analyses fare no better than this:

(84) Further Failures of ALIGN-RIGHT in /C+V/ Juncture

Candidates	CODA-COND	ONSET	ALIGN-RIGHT	FILL
a. ☞ .iñ.čʰi.k|i.		*	*	
b. .iñ.čʰik|.□i.	* !	*		*
c. .iñ.čʰi.k|□.i.		** !	*	*
d. .iñ.čʰi.k|□.□i.		*	*	* ! *
e. .iñ.čʰik|.i.	* !	**		

Under the ranking CODA-COND >> ALIGN-RIGHT, no amount of artifice can achieve satisfactory right Alignment in /C+V/ juncture.

In sum, ALIGN-RIGHT, crucially ranked below CODA-COND and above FILL, yields exactly the correct pattern of faithful versus epenthetic syllabic parsing at stem/suffix juncture. It is paralleled by the nearly symmetric constraint ALIGN-LEFT, which yields a very different phonological pattern: the possibility of initial onsetless syllables. This difference in the effects derived from the two Alignment constraints of Axininca Campa — ALIGN-RIGHT favors an epenthetic parse stem-finally, while ALIGN-LEFT favors a faithful one stem-initially — follows from a crucial difference in ranking. ALIGN-RIGHT pertains to the right edge of the syllable, and it is dominated by CODA-COND, which regulates the segments that can appear at the right edge of the syllable. ALIGN-LEFT pertains to the left edge of the PrWd, hence the left edge of the syllable, and it itself dominates ONSET, which regulates the segments that can appear at the left edge of the syllable. Because they interact differently with these other constraints, ALIGN-RIGHT and ALIGN-LEFT lead to these quite distinct effects on the surface. This is a frequently encountered situation in OT: similar constraints, when embedded in different ranking contexts, can lead to very different empirical results.

Both Alignment constraints also have significant consequences for the augmentation of sub-minimal roots in Axininca Campa. Under conditions explicated below (§6), short roots /CV/ and /C/ are

augmented to bimoraicity. In the current context, what we are concerned with is the form of augmentation, which depends on the shape of the input root:[32]

(85) Augmentation of Sub-minimal Roots in Axininca Campa

a. /CV/ Roots — Disyllabic Augmentation

/na/	.na.□□.	(→ *nata*)	'carry on shoulder'
/t^ho/	.t^ho.□□.	(→ *t^hota*)	'kiss, suck'

b. /C/ Roots — Heavy Syllable Augmentation

/p/	.p□□.	(→ *pa:*)	'feed'

This pattern is entirely regular: /CV/ roots augment to a sequence of two light syllables, while /C/ roots augment to a single heavy syllable. Spring (1990) discovered this generalization, including the crucial evidence in (85b). She relates it, as we do, to the non-coalescence phenomenon, though under very different theoretical assumptions.

Consider first stems /CV/ like *na* 'carry'. There are three principal candidates to examine:

(86) Augmentation of /CV/

a. Monosyllabic:	*.na|□.	(→ **na:*)
b. Disyllabic:	*.na|.□.	(→ **na.a*)
c. Disyllabic:	.na|.□□.	(→ *nata*)

Only augmentation by a full CV syllable .□□, as in (86c), gives both proper alignment and syllabic well-formedness. The form (86b), though it is minimally augmented, obviously violates ONSET. The monosyllabic pattern (86a) is misaligned, because the stem (here identical to the root morpheme) ends amid the long vowel.[33] The following tableau certifies the argument:

(87) Augmentation of /na/

Candidates	ONSET	ALIGN-RIGHT	FILL
a. .na|□.		* !	*
b. .na|.□.	* !		*
c. ☞ .na|.□□.			**

[32] To clarify the examples, we show the expected interpretation of the output phonological representations in parentheses.

[33] This argument rests on the claim that the candidate (86a), phonetically realized as [na:], is misaligned. This is pre-theoretically reasonable, since 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. One representational account of this is presented in McCarthy and Prince (1993:§5), but others are no doubt possible.

Axininca has long vowels elsewhere, so it can only be ALIGN-RIGHT that eliminates the possibility of minimal FILL-violation represented by *na□*. Just as in the analysis of /V+V/ juncture (81), dominant ALIGN-RIGHT forces violations of FILL that aren't justified on purely phonotactic grounds.

ALIGN-RIGHT alone has nothing to say about the **location** of the augmenting syllable. Equally satisfactory alignment is obtained whether epenthesis is initial or final:

(88) Syllabic Augmentation Locational Possibilities
- a. .na|.□□. (→ *nata*)
- b. .□□.na|. (→ **tana*)

But no epenthesis of any kind ever occurs at the beginning of words because of ALIGN-LEFT, which governs **left** edges. ALIGN-LEFT is unviolated and therefore undominated in the constraint hierarchy. Its effects on syllabic epenthesis are shown here, with the sign ''|'' used to mark the left edge of the stem and the bracket ''['' used to mark the PrWd edge:

(89) Initial Alignment Dooms Initial Augmentation
- a. [|na.□□ (→ *nata*)
- b. [□□.|na. (→ **tana*)
- c. [□.|na. (→ **ana*)

These data confirm that ALIGN-LEFT, rather than NO-HIATUS, is responsible for the Initial V phenomenon. Hiatus or onsetlessness is simply not an issue here, since the root /na/ forms an unimpeachable syllable.

ALIGN-RIGHT must also confront augmentation of monoconsonantal roots like /p/ 'feed'. For them, no analysis can simultaneously obtain both syllabic well-formedness and proper alignment. To see this, consider the following candidates, all of which achieve bimoraicity:

(90) Augmentation of /p/
- a. *End-aligned*
  - .□p|. (→ **ap*)
  - .□□p|. (→ **tap*)
- b. *End-misaligned*
  - i. .□.p|□. (→ **apa*)
  - .□□.p|□. (→ **tapa*)
  - ii. .p|□.□□ (→ **pata*)
  - .p|□□. (→ *pa:*)

The only candidates with proper end-alignment are in (90a). But they are doomed by violation of two undominated constraints, ALIGN-LEFT because of initial epenthesis and CODA-COND because of the coda *p*. Of the remaining candidates (90b), neither mono- nor disyllabic modes of epenthesis have any effect whatever on the fundamental misalignment. Initial epenthesis, as in (90bi) is impossible, of course. This leaves only (90bii) as viable candidates, both misaligned at the right edge of the root.

These remaining candidates in (90bii) tie by violating ALIGN-RIGHT. The matter then passes onto the next constraint in the hierarchy, FILL. Guided by the Optimality-Theoretic imperative of minimal violation, it selects the form making least use of empty structure: the monosyllable *p□□*, with only two □'s. This outcome is shown in (91):

(91) Augmentation of /p/ ‘feed’

Candidates	CODA-COND	ALIGN-LEFT	ONSET	ALIGN-RIGHT	FILL
a. ☞ [|p|□□.				*	**
b. [|p|□.□□.				*	*** !
c. [|p|□.□.			* !	*	**
d. [□|p|.	* !	* !	*		*
e. [□□|p|.	* !	* !			**
f. [□.|p|□.		* !	*	*	**
g. [□□.|p|□.		* !		*	***

There is no syllabically well-formed augmentation of the root /p/ that doesn’t also violate ALIGN-RIGHT, because the segment *p* must be parsed as an onset. Initial epenthesis is excluded by ALIGN-LEFT. The decision falls to FILL, at the bottom of the constraint hierarchy, which favors the minimally epenthetic *p□□* over excessively empty *p□.□□*.[34]

[34] What counts as less epenthesis will depend on precisely how FILL is formulated. But all reasonable formulations of FILL give the same result. If FILL measures empty positions without regard to their syllabic role, as reflected by the violation marks in table (91), or if FILL reckons any incomplete syllable as a mark, then *p□□* has fewer than **p□.□□*. If there are separate constraints ‘‘FILL-Nucleus/Mora’’ and ‘‘FILL-Onset’’, as in Prince and Smolensky (1991a, 1991b, 1993), then **p□.□□* but not *p□□* 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^{h}o/, so that the contrast is phonetically apparent:

a. [t^{h}o.|□□. (→ *t^{h}ota*)
b. [t^h□.□o.| (→ **t^{h}ato*)

Both candidates are properly aligned on both edges, so they tie on all relevant constraints. They also are treated equally by all methods of FILL evaluation except for the reckoning of incomplete syllables. In (b), two syllables are crucially incomplete, whereas in (a) 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.

Alternatively, (b) may be disfavored because epenthesis introduces a discontinuity into the root (McCarthy and Prince 1993: §4, p. 50n.). 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 (a) over (b), since these two candidates tie on all other constraints. Kenstowicz (1993) finds additional evidence for such a constraint

Alignment constraints of this type are visibly active in many other languages besides Axininca Campa. They do work that has been sometimes attributed to prosodic domains theory or, as in Axininca, to extrametricality or the cycle. Our goal now is to survey some of the diversity of effects that Alignment constraints on the morphology-prosody interface can lead to, given OT with Gen subject to Consistency of Exponence.

The original case of Alignment, from Prince and Smolensky's (1991b, 1993) analysis of Lardil, is identical to ALIGN-RIGHT in Axininca. In Lardil, prosodic minimality requires that words contain at least two syllables, forcing empty structure in the optimal analysis of a too-small base. The constraint ALIGN-RIGHT functions to regulate the extent of augmentation, explaining the contrast between the patterns in (92). (ALIGN-LEFT is also active in Lardil, barring prothesis, just as in Axininca (89).)

(92) Align in Lardil

Root	*CV-augment*	*V-augment*	
a. /yak/		.ya.k|□.	'fish'
		(→ *yaka*)	
b. /maṛ/	.maṛ|.□□	*.ma.ṛ|□.	'hand'
	(→ *maṛṭa*)	(→ **maṛa*)	

Lardil syllables cannot end in *k*, forcing misalignment of /yak/ in (92a). The root /maṛ/ in (92b), by contrast, is susceptible to syllabification in its entirety. As a consequence, augmentation is driven beyond the absolute minimum: we find a whole CV syllable .□□ where just a vowel would suffice to provide the basis for the required second syllable. Formally, we have ALIGN-RIGHT >> FILL, so that double FILL-violation is compelled when it yields proper right-alignment.

Another case of ALIGN-RIGHT, this time barring epenthesis rather than requiring it, occurs in Bedouin Arabic and Biblical Hebrew (Prince 1975, McCarthy to appear b). These languages show the effects of a constraint proscribing pharyngeal consonants in coda position:

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in the phonology of Chukchee.

(93) CODA-COND (Arabic, Hebrew)
* [pharyngeal] $)_{\sigma}$

As in Lardil, this constraint crucially dominates FILL, leading to epenthesis, as in the following Hebrew examples:

(94) Evidence of CODA-COND >> FILL, in Hebrew

ya.ʕ□.mō̄d	'he will stand'
ye.ħ□.zaq	'he is strong'
ya.h□.pō̄k	'he will turn'
ye.ʔ□.sō̄p	'he will gather'
he.ʕ□.mī̄d	'he made stand'
he.ħ□.zī̄q	'he strengthened'

(The epenthetic vowel □ is realized as identical to the preceding vowel.) Strikingly, however, **stem-final**[35] pharyngeals are firmly anchored in coda position, violating CODA-COND:[36]

(95) Stem-Final Pharyngeal Consonants

šā.maʕ|.	'he heard
šā laħ|.tī	'I sent'
yədaʕ|.tem	'you knew'
yədaʕ|.tī kā	'I knew you'

The facts are very similar in Bedouin Arabic, except that in most dialects satisfaction of CODA-COND leads to metathesis rather than epenthesis. The point in both languages is that ALIGN-RIGHT crucially dominates CODA-COND, forcing the stem-final consonant into syllable-final position, even when it runs afoul of the phonotactics.[37]

The last application of ALIGN-RIGHT that we shall consider is in phenomena usually attributed to final-consonant extrametricality.[38] Consider a language like Kamaiurá (51), in which syllables are strictly open except word-finally, where a single consonant can occur: *apot*. This is standardly analyzed with a maximal CV syllable and final-consonant extrametricality (*cf.*, *e.g.*, Borowsky 1986, Itô 1986, 1989, Rice 1989). Alignment theory permits an alternative conception.

In Kamaiurá, the basic syllable pattern is set by NO-CODA, which must dominate either PARSE or FILL, so that CVC strings can never be faithfully parsed as coda-containing syllables (*cf.* Prince and Smolensky 1993:§6). Let us assume for the sake of illustration that PARSE is crucially dominated. Then a hypothetical input like /hutka/ yields the PARSE-violating, codaless output *huka*:[39]

(96) NO-CODA >> PARSE, from /hutka/

Candidates	NO-CODA	PARSE
a. ☞ .hu.⟨t⟩ka.		*
b. .hut.ka.	* !	

But NO-CODA is itself crucially dominated by ALIGN-RIGHT. This means that the rightmost segment of the stem must be faithfully parsed even if it leads to a NO-CODA violation:

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[35] Stem-final pharyngeal consonants are always **root-final** as well, since they do not occur in affixes.

[36] The 1st pl. with object suffix is an exception: *yəda.ʃ/□.nū kā* 'we knew you'.

[37] As in Axininca, ONSET >> ALIGN-RIGHT, so e.g. /šā maʕ –ū/ → *šā mə.ʃ/ū*, with the stem-final consonant parsed as an onset.

[38] Thanks to Greg Iverson and Kelly Lietz for pointing this out.

[39] Of course, in such conditions a form like /hutka/ will never be posited as a lexical entry in the absence of evidence from alternations that the /t/ is there. The principle of *Lexicon Optimization* in Prince and Smolensky (1993:§9, p. 192) militates against choosing underlying forms that lead to gratuitous constraint violations, formalizing a theme from the work of Stampe (1969, 1973/9).

(97) ALIGN-RIGHT >> NO-CODA, from /apot/

Candidates	ALIGN-RIGHT	NO-CODA	PARSE
a. ☞ .a.pot|.		*	
b. .a.po.⟨t⟩|	* !		*
c. .a.po.t|□.	* !		

The final consonant of the optimal candidate (97a) is actually parsed as a syllable coda, in violation of NO-CODA. It is not ''extrametrical'' in any sense. The final consonant of the failed candidate (97b) is worse than extrametrical: it is not parsed at all, leading to erasure and non-pronunciation when this representation is interpreted. Failure to parse the final consonant, as in (97b), or parsing it with a final epenthetic vowel, as in (97c), de-aligns the stem. In this way dominant ALIGN-RIGHT yields the pattern of codaless medial syllables combined with the possibility of a coda word-finally.[40]

ALIGN-LEFT in Axininca Campa and ALIGN-RIGHT in Kamaiurá illustrate a general approach to so-called edge-of-constituent effects, where expected phonotactic patterns are disrupted in peripheral position. These effects arise when Align(GCat, E, PCat, E) >> $\wp$, where $\wp$ stands for some phonotactic constraint that affects the composition of the edge E of PCat. For ALIGN-LEFT in Axininca Campa, $\wp$ = ONSET, and for ALIGN-RIGHT in Kamaiurá, $\wp$ = NO-CODA. Obviously, additional cross-linguistic possibilities can be obtained with other values of GCat and PCat, as well as other choices of $\wp$, such as constraints regulating the complexity of onset or coda clusters or the maximum weight of syllables.

In standard accounts, the phenomena in Axininca Campa and Kamaiurá would be (and are) analyzed by extrametricality. Inkelas's (1989:144ff.) influential proposal is that extrametricality is just exactly a **misalignment** of prosodic and morphological constituents. Here, though, we have argued that some phenomena that have been analyzed by extrametricality actually reflect constraints on the **alignment** of prosodic and morphological categories. More broadly, results in OT suggest that proposed mechanisms of ''extrametricality'' or ''invisibility'' attempt (less than successfully) to conflate unrelated empirical phenomena, which can be seen to fall out from distinct substantive constraints. This point is introduced and developed by Prince and Smolensky (1993: §4.3) in the context of metrical stress theory and is further developed for negative prosodic circumscription above in §4 and for stress in Hung (in prep.).

Another class of Alignment effects derives from the Prosodic Hierarchy, and subsumes traditional statements to the effect that a morphological boundary is ''opaque'' to prosodification. A constraint of the ALIGN-LEFT type requires that the left edge of each stem coincide with the left edge of a PrWd. But it also entails that the left edge of the stem not lie **within** a syllable or **within** a foot, since σ and Ft are subordinate to PrWd in the Prosodic Hierarchy. Thus, a well-aligned stem-edge is opaque to syllable-parsing and to foot-parsing.

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[40] Other accounts of Kamaiurá are possible under Generalized Alignment. The analysis in the text assumes that the final *t* of *apot* is a coda, but suppose it could be established on phonological grounds that it is actually an appendix (a segment parsed directly by PrWd (Rubach and Booij 1990)). Then the dominant alignment constraint must be Align(Stem, R, **PrWd**, R), which requires coincidence of stem-edge and PrWd-edge (not syllable-edge). This crucially dominates a constraint NO-APPENDIX, which prohibits appendices (cf. Sherer in prep.). For further remarks on the relationship of ALIGN-RIGHT(MCat, σ) and ALIGN-RIGHT(MCat, PrWd), see below §5, p. 56.

Polish is a case of this type, exhibiting phenomena that have been analyzed in terms of the domains of prosodization rules or the opacity of morphological constituents to prosodization. Rubach and Booij (1990:442) (see also Szpyra 1989:178f.) observe that Polish does not permit syllabification between words or in prefix+stem juncture, as in (98).

(98) Impossibility of Junctural Syllabification in Polish

a.	mechanizm. |obronny	'defense mechanism'
	*mechaniz.m |obronny	
b.	roz.|ognić	'heat'
	*ro.z|ognić	

They propose that this syllabification is required by a Prosodification Constraint, according to which ''Derivation of prosodic structure is blocked by the constituency bracket [.'' Their ''['' corresponds to our left stem-edge ''|''.

Rubach and Booij's Prosodification Constraint, though cast within a rule-based theory, translates directly into ALIGN-LEFT: Align(Stem, L, PrWd, L). Because PrWd dominates σ in the Prosodic Hierarchy, the stem-edge cannot lie within a syllable, if ALIGN-LEFT is to be satisfied. Thus, syllabification across /C|V/ juncture is fatally de-aligning, as the tableau (99) demonstrates:[41]

(99) ALIGN-LEFT >> ONSET, from /mechanizm obronny/

Candidates	ALIGN-LEFT	ONSET
a. ☞ [.|mechanizm] [.|obronny]		*
b. [.|mechaniz] [.m|obronny]	* !	

In (99a), each stem-edge ''|'' aligns with a PrWd-edge ''['' . But in (99b), the second stem-edge lies inside a syllable. Since, by the Prosodic Hierarchy, a PrWd-edge cannot occur inside a syllable, (99b) violates ALIGN-LEFT, with deadly results. Thus, undominated ALIGN-LEFT bans trans-junctural syllabification. This is identical to the result shown for the hypothetical Axininca Campa example in (79).

ALIGN-LEFT also has consequences for stress in Polish, through interaction with other constraints. By the Prosodic Hierarchy, no foot can straddle two PrWd's, so each stem is a separate domain for foot-parsing, as shown by examples like the following (Rubach and Booij 1990:443):

(100) Foot-Parsing in Polish Stems

[|nor(wésk–o)][|(pólsk–i)] 'Norwegian-Polish'

The active prosodic constraints in Polish foot-parsing are given above in (32d). The prosodic constraint responsible here is Align(PrWd, R, Ft, R), which requires that each right PrWd-edge coincide with a right

[41] Satisfaction of ALIGN-LEFT entails that prefixed forms are parsed with PrWd-recursion: [|roz[|ognić]]. That is, both the stem *rozognić* and the stem *ognić* are PrWd's. The effects of this are roughly equivalent to Rubach and Booij's (1990:459-61) derivational account, in wich prefixes are adjoined to PrWd postcyclically.

foot-edge. Thus, each stem begins with a Prosodic Word, and each Prosodic Word ends with a foot, just as in (100).

In Polish or Axininca Campa, ALIGN-LEFT is undominated and therefore unviolated in all output forms. But if ONSET >> ALIGN-LEFT, de-alignment inevitably ensues. Nonetheless, ALIGN-LEFT may still be visibly active, depending on what other constraints there are in the system. This situation, where even a dominated constraint may have effects on the output, is typical of OT.

One such case is English, where ALIGN-LEFT governs the distribution of ambisyllabicity at word-juncture. Kahn (1976) observes that word-final consonants are parsed as ambisyllabic before vowel-initial words (101a), but word-initial consonants are not parsed as ambisyllabic after vowel-final words (101b):

(101) Ambisyllabicity and Heterosyllabicity at Word Juncture in English

a. /C–V/ Juncture — Ambisyllabicity

sought Ed	=	[sɔɾɛd]

b. /V–C/ Juncture — Heterosyllabicity

saw Ted	=	[sɔt^{h}ɛd]

In Kahn's analysis, flapping of /t/ is diagnostic of ambisyllabicity in American English. Thus, (101a, b) differ crucially in prosodic structure; /t/ is ambisyllabic in (101a), but it is a pure onset in (101b).

The prosodic constraints relevant here are ONSET and FINAL-C. The latter, justified in McCarthy (to appear a), requires that any PrWd end in a consonant.[42] ALIGN-LEFT is also relevant, and in fact it is responsible for the contrast between (101a) and (101b).[43] The constraint hierarchy required is ONSET >> ALIGN-LEFT >> FINAL-C, as shown in the following tableaux, which represent the candidates with the three possible syllabic parses of the junctural /t/:

[42] The justification for FINAL-C rests primarily on the *r* intrusion phenomenon in the Eastern Massachusetts dialect. Intrusive *r* occurs after lexical words but not after function words: *Wanda[r] eats* but *I wanna eat*, **I wanna[r] eat*. This contrast follows from FINAL-C if lexical words, but not function words, are parsed as PrWd's.

[43] Brian O'Herin and Philip Spaelti pointed this out, on behalf of the UC Santa Cruz Phonology Reading Group.

(102) Optimal Ambisyllabic Parse of *sought Ed*

Candidates	ONSET	ALIGN-LEFT	FINAL-C
a. PrWd PrWd σ σ sought Ed	* !		
b. PrWd PrWd ☞ σ σ sought Ed		*	
c. PrWd PrWd σ σ sought Ed		*	* !

When the stem is vowel-initial (102), ONSET eliminates the one candidate (102a) that is properly aligned. The remaining candidates (102b, c) are both mis-aligned, but only the former also satisfies the requirement that any PrWd must end in a consonant.

(103) Optimal Heterosyllabic Parse of *saw Ted*

Candidates	ONSET	ALIGN-LEFT	FINAL-C
a. PrWd PrWd σ σ saw Ted	* !	*	
b. PrWd PrWd σ σ saw Ted		* !	*
c. PrWd PrWd ☞ σ σ saw Ted			*

When the stem is consonant-initial (103), ALIGN-LEFT, even though dominated by ONSET, comes into play, demanding the sharp coincidence of stem-edge with PrWd-edge. It is violated whenever a stem-initial consonant is (also) parsed by a different PrWd (103a, b). Thus, it rejects the ambisyllabic parse in /V–C/ juncture.[44]

Another way that ALIGN-LEFT can be visibly active even if dominated is if its evaluation of candidates is gradient rather than categorical. The reason for this is that, though crucial domination leads to violation, the Optimality-Theoretic imperative of **minimal** violation is important in assessing the different degrees to which gradient ALIGN-LEFT is violated.

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[44] Some care is required to complete the argument at the level of formal detail. One approach runs as follows. For purposes of ALIGN-LEFT we need a string that *is a* PrWd, whose first element is also the first element of the Stem. But in (103b) the string *Ted* fails to stand in the *is a* relationship to the node PrWd, in the sense that if all the (graph-theoretic) edges emerging from its terminals are traced upward, they do not converge on the one PrWd node. Therefore there is no string that *is a* PrWd in this upward sense (although tracing downward from PrWd would yield the string *Ted* as its contents), and the constraint cannot be met. The sketch of formal Alignment at the end of §2 is based on the superannuated notion that linguistic structures correspond to acyclic graphs — trees, in particular; given dual motherhood of nodes, we must sharpen our sense of *is a*. For discussion of the related issue of the de-aligning effect of feature spreading, see McCarthy and Prince 1993:39-40. For careful formalization of autosegmental structure, see Kornai (1992) and Pierrehumbert and Beckman (1988: ch. 6); the latter specifically addresses the issue of defining ‘‘edge’’ in autosegmental representations.

German and Dutch (Booij to appear:§3.4.1) are cases of this type. In German, for example, syllabification across a left stem-edge is impossible, but ONSET is nonetheless obeyed, by epenthesis:

(104) Left Stem-edge Opacity in German

a.	ver–ʔirren	'to lose one's way'	
	auf–ʔessen	'to eat up'	
b.	Zoll–ʔamt	'customs-house'	
	Rei[p]–ʔeisen	'grater'	/reib–…/
	Ber[k]–ʔab	'downhill'	/berg–…/

The prefixed forms in (104a) and the compounds in (104b) display the same pattern: the left edge of the stem is an impervious barrier to syllabification. (Coda devoicing in (104b) confirms this.) Still, in both cases the stems are de-aligned by ONSET-satisfying *ʔ*.

There are three interesting candidates for the parse of these /C–V/ junctural examples:

(105) Candidates of Interest from /C–V/, in German

Candidates	ONSET	ALIGN-LEFT	FILL
a. auf [.|essen	* !		
b. ☞ auf [.□|essen		□	*
c. au [.f|essen		f !	

The first candidate (105a) is well-aligned but violates ONSET fatally. ONSET is among the undominated constraints of German, forcing FILL-violation even phrase-initially. The remaining candidates (105b, c) are impeccable ONSET-wise, and if FILL were all that mattered, we would expect (105c) to triumph over (105b). But FILL isn't all that matters; ALIGN-LEFT also distinguishes the two forms, based on the nature of the material intervening between the stem-edge and the PrWd-edge.

To make use of this distinction, we require a theory of gradient violation of Alignment. We already have such a theory in hand, from the discussion (§3, §4) of Alignment in stress and infixation. As shown in (31) or (43), the optimal candidate among a set of Align violators is the one whose violation-string is contained in all other violation-strings, where the violation-string is the material separating the two specified edges. In cases like (31) or (43), the optimal violation-string is just a substring of all the others; in (105b), the violation-string □ is a sub-tree of (105c)'s violation-string *f*. The element □ is a feature-geometric Root node with no dependents; the consonant *f* has a Root node, plus the various dependent feature that make up an *f*. Thus, □ is contained within *f*, so (105b) violates ALIGN-LEFT less than (105c) does.[45]

Malay and Indonesian (Durand 1987; Cohn 1989; Cohn and McCarthy in prep.) show yet another effect of ALIGN-LEFT, but this time on /V+V/ hiatal junctures. First some background. Cohn (1989)

[45] Under other assumptions about phonological representation (see the references in §2), the element □ is a skeletal slot with no dependent segment. Since *f* has a skeletal slot as well as a dependent segment, the identification of the minimal violation of ALIGN-LEFT is the same.

proposes a rule with the same effect as ALIGN-LEFT in her analysis of Indonesian stress. The principal evidence for this rule, and therefore for ALIGN-LEFT in this language, comes from the opacity of the left stem-edge to foot-parsing. The basic grammar of foot-parsing in Indonesian is identical to that of Garawa in §3, so the comparison is straightforward:

(106) Opacity of Left Stem-Edge to Foot-Parsing in Indonesian

	ALIGN-LEFT Obeyed	ALIGN-LEFT Violated	
a.	di [(|cát)]	*[(dí|cat)]	'printed'
	di [|ko(réksi)]	*[(dì|ko)(réksi)]	'corrected'
b.	[(|càp)] [(|pós)]	*[(|cáp|pos)]	'postmark'
	[|wa(níta)] [|wa(níta)]	*[(|wàni)(tà|wa)(níta)]	'women'

Since a root is a stem, ALIGN-LEFT requires in particular that the left edge of each root (indicated by ''\|'') coincide with the left edge of a PrWd (indicated by ''['']). The forms in the left-hand column respect this requirement, whether prefixed (106a) or compounded (106b). The forms in the middle column transgress it flagrantly, by parsing the root-initial syllable in the same foot (and therefore the same PrWd) as a preceding syllable. These facts show that ALIGN-LEFT is high-ranking in Indonesian.

ALIGN-LEFT also has segmental and syllabic consequences in Malay/Indonesian, closely paralleling the case of German. Normally, when the first of two vowels in hiatus is high and the second of the two is not identical to the first, then a glide homorganic to the first vowel resolves the hiatus:[46]

(107) Resolution of Hiatus in Malay/Indonesian

/diam/	di.**y**am	'quiet'
/buah/	bu.**w**ah	'fruit'
/uji–an/	uji.**y**an	'test'
/bantu–an/	bantu.**w**an	'aid, relief'

The glide observed in these forms can be plausibly regarded as the result of parsing the high vowel ambisyllabically, as the nucleus of one syllable and the onset of the next. But an ambisyllabic parse is de-aligning (102, 103), so it runs afoul of ALIGN-LEFT when the hiatus occurs across the left stem-edge. In that case, FILL-violation, signalled by phonetic *ʔ*, is found instead:

(108) Resolution of Stem-Initial Hiatus in Malay/Indonesian

/di–ankat/	di [.ʔ|ankat	'be lifted'
	*di [.y|ankat	
/di–ukir/	di [.ʔ|ukir	'be carved'
	*di [.y|ukir	
/api–api/	api [.ʔ|api	'fires'
	*api [.y|api	

The choice here, as in (105), is between two degrees of violation of ALIGN-LEFT. The worse violation separates the left stem-edge from the syllable-edge (and therefore the PrWd-edge) by a full segment, and

[46] When the first vowel is non-high or when the second vowel is identical to the first, hiatus is resolved by *ʔ*. See Rosenthall (in prep.) for a discussion of the additional constraints responsible for this.

moreover a segment that is sponsored by a morpheme outside the stem. The better violation mis-aligns by only the empty segment □, realized as glottal stop.

The German and Indonesian examples illustrate how the requirement of minimal violation permits a gradient ALIGN-LEFT constraint to be visibly active even when crucially dominated by ONSET. On the other hand, gradient assessment of violation of ALIGN-RIGHT in Axinica Campa would yield the wrong result for the examples (91a) *p*/□□ versus (91b) **p*/□.□□. The former is mis-aligned by □□, while the latter is mis-aligned by just □. Nevertheless, *p*/□□ is optimal. This result follows in (91) if all violations of ALIGN-RIGHT are reckoned equally, so the tie is passed along to FILL. It would appear then, based on our current rather primitive understanding of the situation, that the possibility of gradient versus categorical evaluation of Alignment at the prosody-morphology interface is a parameter to be set in the specification of individual constraints.[47]

In this section, we have seen a variety of applications of GA constraints of the form Align(GCat, Edge, PCat, Edge), requiring that the left (resp. right) edge of every instance of GCat coincide with the left (resp. right) edge of some PCat. Two types of such constraints have been discussed here, and a remarkably wide range of empirical consequences of these constraints have been identified:

(109) Summary of Effects of Align(GCat, PCat)

a. ALIGN-LEFT: Align(Stem, L, PrWd, L)
   - i. Axininca Campa initial-V phenomenon (77, 78, 79).
   - ii. Axininca Campa ban on prothetic augmentation (89, 90a, 90bi).
   - iii. Lardil ban on prothetic augmentation (92).
   - iv. German, Polish, Malay/Indonesian ban on trans-junctural syllabification (99, 105, 108).
   - v. English ambisyllabification asymmetry (102, 103).

b. ALIGN-RIGHT: Align(Stem, R, σ, R)
   - i. Axininca Campa non-coalescence of /V+V/ (80).
   - ii. Axininca Campa form of augmentation (87).
   - iii. Lardil form of augmentation (92).
   - iv. Hebrew, Bedouin Arabic preservation of pharyngeal codas (95).
   - v. Kamaiurá final consonant ‘‘extrametricality’’ (97).

Just these two constraints, both instances of GA, derive this variety of effects. They can do so because they rely on two central claims of OT. First, the constraints evaluate outcomes; they say nothing about the processes leading to those outcomes. From the processual standpoint, the consequences of Alignment inventoried in (109) are quite diverse, including effects on consonant or vowel epenthesis, syllabic augmentation, re- and ambisyllabification, coalescence, and deletion. These processes have nothing in common, except that they happen to include all of the phonological phenomena that can affect the relation between the edge of a stem and the edge of a prosodic constituent such as PrWd or syllable. Second, in many of the cases considered, these two Alignment constraints are ‘‘simply false’’, in the sense that they are violated in some output forms. Thus, ALIGN-LEFT is violated, minimally, by *ʔ*-epenthetic forms in German or Malay/Indonesian and by ambisyllabic /C–V/ junctural forms in English. Likewise, ALIGN-RIGHT is violated by /C–V/ (and /C–C/) junctural forms and /C/ roots in Axininca Campa, by Lardil roots like /yak/ that end in illicit codas, and by /C–V/ junctural forms in Hebrew or Bedouin Arabic. Systematic interaction rather than atomic truth is fundamental to the Optimality-Theoretic view

[47] ALIGN-LEFT can also be violated categorically, in languages like Arabic, French, Spanish, Ancient Greek, and so on, that allow uninhibited syllabification across morphological junctures.

of constraints, and it pervades the actual phonology of these constraints on the morphology-prosody interface.

An issue of great theoretical interest is the asymmetry between ALIGN-LEFT and ALIGN-RIGHT in their reference to prosodic categories: ALIGN-LEFT makes the stringent demand that the stem begin with a PrWd, where ALIGN-RIGHT is content with ending the stem on a syllable. In fact, the reverse situation is linguistically possible — for final alignment to be in terms of PrWd, or initial alignment to be in terms of σ. In Shona and Mohawk, for example, augmentative epenthesis is initial rather than final (Myers 1987, Hewitt 1992; Michelson 1988), exactly the opposite of Lardil and Axininca Campa.

How might this symmetry be brought out? Suppose that ALIGN-RIGHT were in fact always to be stated as Align(Stem, R, PrWd, R), just exactly the edge-flipped version of ALIGN-LEFT, contrary to our descriptive practice so far. With ALIGN-LEFT dominant, as surely it must be in Lardil and Axininca Campa, violation of ALIGN-RIGHT can then be forced. The crucial measure of violation must be hierarchical-categorical rather than in terms of distance-from-the-edge. ALIGN-RIGHT places two distinct requirements on the stem: (1) that its right edge must also be the right edge of a prosodic category, and (2) that the prosodic category be PrWd. In ALIGN-RIGHT as we have seen it, the second demand can be abrogated while the first is enforced. In Axininca, an augmented form like *.na*|.□□., in which the stem is coterminous with a syllable but not a PrWd, is superior to the alternative *.*na*|□., where the stem is aligned with neither syllable nor (*a fortiori*) PrWd. Choice of the syllable-aligned version would thus represent a kind of minimal violation of the constraint. These examples show clearly that distance from the categorically-designated edge (as in Prince and Smolensky's original EDGEMOST) cannot be relevant here, for then the ungrammatical *.*na*|□.] would certainly be reckoned superior to the correct form *.na*|.□□.].

At present, it is not clear how such distinctions in mode of violation are to be taken account of, and we must leave the matter open for future exploration. The notion of minimal violation is a powerful explanatory tool of great generality, and every effort should be made to understand its consequences and to test its limits. It is clear, however, that pursuing this line of reasoning can lead to considerable sharpening of the theory of the prosody/morphology interface. In particular, it may well be that, under prosodic-morphological principles, **stem** can be related to or replaced by only **PrWd**. In the Ulwa phenomenon discussed above, for example, suffixation to the Stem is supplanted by suffixation to Ft′, the head of the PrWd, or (along the lines of McCarthy and Prince 1990, 1991ab) the smallest possible PrWd within the larger PrWd that constitutes the stem. (Diverse restrictions of the same kind on the canonical or templatic form of stems and stem-like constituents can be found in e.g. McCarthy and Prince 1990a, 1991ab, to appear (and references cited therein); Prince 1990/1). Significantly, affixation to σ is never found, although the purely formal theory of Alignment would certainly allow it. The observed sensitivity of ALIGN-RIGHT to syllable rather than PrWd edges in the cases reviewed here thus stands out against the prosodic-morphological background as a distinctive anomaly. We suggest that it may find its explanation in the notions of constraint dominance and minimal violation: in those languages where ALIGN-LEFT >> ALIGN-RIGHT, a minimal categorical violation of ALIGN-RIGHT leads to alignment with σ being evaluated as more harmonic that no alignment at all. The opposite ranking, as in Shona or Mohawk, places the more stringent requirement on the trailing edge.

§6. Generalized Alignment and Prosodic Subcategorization

One type of constraint introduced in §4, exemplified by ALIGN-FOOT in Ulwa (58), requires the coincidence of **different** edges of the targeted GCat and PCat. In Ulwa, the left edge of the GCat $[ka]_{Af}$ must align with the right edge of the head foot Ft′. This is a species of **prosodic subcategorization** (*cf.* Broselow and McCarthy 1983, Inkelas 1989, Booij and Lieber to appear), in which a morphological constituent, an affix, requires a prosodic constituent of a particular type to attach to.

In Ulwa, the subcategorizational constraint ALIGN-FOOT leads to surface infixation, since the suffixational constraint Align(Affix, R, Stem, R) is crucially dominated. But in other phonological systems, with different interacting constraints, prosodic subcategorization can lead to effects that one would not naively guess to be related to infixation. Such is the case in Axininca Campa, where a subcategorizational Alignment constraint is responsible for a very particular pattern of augmentation of sub-minimal roots.

First some background. The Prosodic Hierarchy and Foot Binarity (17), taken together, derive the notion ‘‘Minimal Word’’ (Prince 1980, Broselow 1982, McCarthy and Prince 1986, 1990, 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. The foot, and therefore the PrWd, is minimally bimoraic in languages that make distinctions of syllable weight (‘‘quantity-sensitive’’ languages); it is minimally disyllabic in languages that make no weight distinctions (‘‘quantity-insensitive’’ languages). Observed word minimality restrictions therefore follow from the grammatical requirement that a certain morphological unit, often Stem or MWd, must correspond to a Prosodic Word.

Identifying a morphological unit like stem as a PrWd has, then, characteristic consequences for the size and shape of the unit. A particularly interesting pattern of minimality effects is found in Axininca Campa (McCarthy and Prince 1993:§4). Under certain conditions, short roots /CV/ and /C/ are augmented to bimoraicity. Above in §5 we accounted for the form taken by the augment in the two types of sub-minimal roots. Our goal now is to treat the conditions under which augmentation occurs.[48]

The conditions of augmentation or non-augmentation in Axininca Campa are exemplified in the table (110), using the root *na* ‘carry on shoulder’ in combination with the suffixes *-aanc^{h}i* ‘infinitive’, *-piro* ‘verity’, and the reduplicative *-RED* ‘more and more’:

(110) Conditions of Augmentation

	__+V…	__+C…	__+RED
Aug.		na.□□–piro□aanc^{h}i	na.□□–na.□□–wai□aki
Nonaug.	na–□–aanc^{h}i	no-na–piro□i	no-na–nona–wai□i

The other sub-minimal root-type, represented by /p/ ‘feed’, behaves identically, except for the difference in form of augmentation analyzed in §5. Obviously, augmentation is to bimoraicity, as expected, since the prosody of the language is quantity-sensitive. Less obvious are the conditions under which augmentation occurs:

[48] Previous work on Axininca Campa has also attributed augmentation to word minimality, but without a complete account of the conditions leading to augmentation (Itô 1989:239, Spring 1990:140-163, Black 1991:202-204).

i. **Bareness**.
Only a bare root is augmented.
When a prefix is present, nothing happens.
ii. **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 conditions, the first, *Bareness*, is grounded in a grammatical property independent of augmentation. It reflects the fact that prefix and root join together to form a stem, independently required in the lexical organization of the language (McCarthy and Prince 1993:§3). When a PrWd requirement falls on the stem, any prefix that is present must count toward satisfying it.

Condition (ii), *Suffix-initial C*, is more mysterious: why should augmentation occur only before C-initial suffixes and the reduplicative affix? It will emerge that this follows from a species of Alignment constraint, and Consistency of Exponence, as well as the possibility of constraint violation, will play a crucial role in the explanation.

Spring's (1990:140-63) proposal that the *base of reduplication* is a PrWd is a first step toward accounting for this. This means that the base to which the reduplicative suffix –RED is attached must be a PrWd. Consequently, the PrWd base of reduplication must display augmentation to bimoraicity.

This idea accounts for augmentation under reduplication, but it says nothing about augmentation before C-initial suffixes or the corresponding lack of augmentation before V-initial suffixes. Instead, we propose that the apparent phonological restriction to ''C-initial suffixes'' is a descriptive artifact. The linguistic principle responsible for augmentation 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:

(111) ALIGN-SFX
Align(Affix, L, PrWd, R)

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.

Like ALIGN-RIGHT and ALIGN-LEFT, this constraint governs the morphology-prosody interface, demanding alignment of the edge of a morphological constituent with the edge of a prosodic constituent. Unlike them, however, it is subcategorizational, in the sense that it requires that every suffix abut a PrWd rather than be aligned within one. Once it has been properly integrated into the grammar through ranking, this constraint will guarantee, through interaction with FT-BIN and other prosodic constraints, that any structures obeying it will have a pre-suffixal string at least two moras in size. More importantly, interaction with other constraints will turn out to distinguish successfully between C-initial and V-initial suffixes, in much the same way as ALIGN-RIGHT distinguishes /V+V/ juncture from /C+V/ juncture, or the augmentaton of /C/-roots from that of /CV/-roots (§5).

First, the C-initial suffixes. The only crucial assumption here is that ALIGN-SFX dominates FILL, so that the Alignment constraint can compel epenthesis. The following tableau assesses the chief alternative candidates:

(112) C-initial suffixation of /na/

Candidates	FT-BIN	ALIGN-SFX	FILL
a. na|piro		* !	
b. na]|piro	* !		
c. ☞ na.□□]|piro			**

The left edge of the suffix is indicated by ''|'', as usual. If ALIGN-SFX is obeyed, the constituent-edge so marked should coincide with the right edge of PrWd, indicated by '']''. Of the candidates, only (112c) meets ALIGN-SFX and maintains 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:

- Form (112a) **na*/*piro* violates ALIGN-SFX, since /*piro* is not immediately preceded by a PrWd.
- Form (112b) *[*na*]/*piro* proffers a monomoraic PrWd, in fatal violation of the foot binarity requirement FT-BIN.

These candidates fail in the face of the actual output form [*na.□□*]/*piro*, which violates only the lower-ranked constraint FILL. Before any C-initial suffix, then, a subminimal root will be augmented to bimoraicity.

ALIGN-SFX also derives augmentation of the Base under reduplication. Because the reduplicative morpheme is a suffix, it wants a preceding PrWd just like any other suffix. Reduplicative suffixes are always consonant-initial, for reasons developed in McCarthy and Prince (1993:§5.2). Thus, reduplicative suffixation will induce augmentation of a subminimal Base just like any other consonant-initial suffix:

(113) Reduplication of /na/

Candidates	FT-BIN	ALIGN-SFX	FILL
na.|na		* !	
na.]|na	* !		
☞ na|.□□] |na.□□			****

The details of the argument here are identical to that given in the discussion of tableau (112) above. The optimal form obtains prosodic well-formedness (FT-BIN) as well as proper alignment at the left suffix-edge (ALIGN-SFX), violating only FILL. The other candidates trade violation of FILL for worse infractions, a fatal exchange given FILL's subordinate position in the hierarchy.

In contrast, V-initial suffixes present an irreconcilable conflict between ALIGN-SFX and prosodic well-formedness. ALIGN-SFX wants the following configuration:

(114) ALIGN-SFX with V-initial Suffix

]|V

There is simply no way to achieve this configuration that's consistent with syllabic well-formedness. The V in (114) has to be syllable-initial since, under the Prosodic Hierarchy, no PrWd-edge can lie within a syllable. But if the V is syllable-initial, the direct assault of augmenting in the style of the C-initial suffixes runs afoul of ONSET:

(115) Hypothesized Augmentation of /na+aanc^{h}i/
*na.□□].|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 ALIGN-SFX.

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

(116) Hypothesized Augmentation and Epenthesis of /na+aanc^{h}i/
*na.□□].□|aan.c^{h}i

Ill-aligned and augmented *na.□□.]□|aanc^{h}i* must then face ill-aligned and unaugmented *na.□]aanc^{h}i*. With ALIGN-SFX out of the equation, failed by both serious candidates,[49] the decision falls to FILL, which could care less about word minimality. The most faithful candidate, most conservative in epenthesis, is selected: *na.□aanc^{h}i*, with no syllabic augmentation.

V-initial suffixes, then, simply **cannot** be properly aligned with a PrWd-edge and at the same time satisfy the high-ranked constraints on syllable structure. Since proper Alignment suffers in the conflict, the ranking ONSET >> ALIGN-SFX is in effect, and so the crucially dominated ALIGN-SFX imposes no requirements whatsoever on the prosody preceding a V-initial suffix. Hence there is no augmentation, and the only epenthesis seen is a result of purely syllabic conditions, ONSET in particular. This argument is laid out with a set of plausible candidates[50] in tableau (117):

[49] This result follows only if violation of ALIGN-SFX is reckoned categorically, not gradiently. Compare the discussion of gradient versus categorical evaluation of ALIGN-LEFT and ALIGN-RIGHT violation in §5.

[50] Another logically possible treatment of /V+V/ juncture is segregation of base and suffix into two completely separate PrWd's: [*na.□□*][|*aanc^{h}i*]. This actually happens in some reduplicative configurations in Axininca Campa (McCarthy and Prince 1993:§5.4), but it's not possible with an ordinary suffix like *–aanc^{h}i*. This follows from the requirement, familiar from the sentence-phonology literature (e.g., Selkirk (1984:343) and *cf.* Nespor and Vogel (1986:109-144)), that every PrWd contain a root.

(117) V-initial Suffixation /na+aanc^{h}i/

*Candidates	ONSET	FT-BIN	ALIGN-SFX	FILL
a. na].|aanc^{h}i	* !	* !		
b. na.□□].|aanc^{h}i	* !			**
c. na.|aanc^{h}i	* !		*	
d. na.□□].□|aanc^{h}i			*	*** !
e. ☞ na.□|aanc^{h}i			*	*

The candidates (117a, b) are properly aligned, but stumble on syllabic and prosodic well-formedness, enforced through dominant constraints. Example (117c) avoids FT-BIN and FILL violation, but is neither properly suffix-aligned nor syllabically well-formed. The last two examples (117d, 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. These results show that the pattern of augmentation only before C-initial suffixes follows from one crucial ranking, ONSET >> ALIGN-SFX.

Two further issues remain. First, what are the effects of ALIGN-SFX on affixation to longer stems, two moras or more in length? No effects are desired, since only sub-minimal roots are ever augmented. No effects are predicted either. The only relevant environment is before C-initial suffixes, because this is the only environment where ALIGN-SFX 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 pre-suffixal string is satisfied by what's already there underlyingly, and augmentation would constitute gratuitous FILL-violation.

Second, what are the effects of multiple C-initial suffixes within a single word? The expected result is recursion of PrWd, illustrated by /na–RED–wai–ak–i/:

(118) Recursion of PrWd

[[[na.□□.]|na.□□.]|wai.□|a.k|i]

In this example, PrWd-hood is imposed on *na.□□* by the suffix –RED, as evidenced by the augmentation. The continuative suffix *–wai* also imposes PrWd-hood on *na.□□.na.□□*, though vacuously, since FT-BIN is satisfied without further ado. The remaining suffixes, *–ak* and *–i*, cannot satisfy ALIGN-SFX without violating ONSET or CODA. General considerations of parsing (*cf.* PARSE-SYLL (19)) require that the entire form be parsed as a single PrWd. Thus, the subcategorizational constraint ALIGN-SFX yields recursive prosody, exactly like the result of prosodic subcategorization in Inkelas (1989:97ff.). The stress-related phonology of Axininca gives no evidence of the internal PrWd's, though, so in McCarthy and Prince (1993:§A.1) we propose a principle, akin to Bracket Erasure in Lexical Phonology (Pesetsky 1979, Kiparsky 1982, Mohanan 1982, Inkelas 1989), that simplifies the recursive structure prior to the level at which surface stress is determined. Another aspect of the language, the phonology of the velar glide, confirms the need for such a level.

In this section, we have shown that a subcategorizational alignment constraint, ALIGN-SFX, leads to augmentation of sub-minimal roots. The principal result is to confirm the existence of constraints of the form Align(GCat, Edge1, PCat, Edge2), Edge1 ≠ Edge2, in cases other than infixation. A very

particular aspect of augmentation, the limitation to stems before C-initial suffixes, follows from the ranking ONSET >> ALIGN-SFX, which leads to de-alignment and consequent lack of augmentation before V-initial suffixes. As in §5, an essential aspect of the explanation is Consistency of Exponence, which establishes the left edge of the suffix as a fixed landmark throughout all candidates supplied by Gen.

§7. Conclusion

In this article, a theory of categorial **alignment** has been developed. We have argued that violable constraints demanding the alignment of prosodic or morphological constituents underlie a wide range of linguistic phenomena. Because of their greater generality of formulation as well as their empirical superiority, they improve significantly upon the results obtained previously through diverse mechanisms like the phonological cycle, extrametricality, iterative foot-parsing, and prosodic circumscription. Many — perhaps all — of the various modes of reference to constituent edges in grammar can be subsumed under a single schema, called here Generalized Alignment. The essential formal idea is to distinguish conditions on hierarchy (category X must/can contain category Y) from conditions on collocation; the collocational restrictions are handled by conditions on the sharing or alignment of specified edges of specified categories. This provides a formal means to define not only the admissible patterns within a single hierarchical (tree-structured) grouping, but also to define the relations between categories belonging to different hierarchies, when they partially share a terminal string (particularly the hierarchies of prosody and morphology).

Four principal types of descriptive results have been obtained here through application of GA:

• **Footing Patterns.** In prosody proper (§3), the locus of foot-parsing within the Prosodic Word was analyzed by the constraints Align(PrWd, Ft) and Align(Ft, PrWd). The former requires requires a single foot left- or right-aligned within the PrWd; the latter, replacing foot iteration in standard metrical theory, requires that **any** foot lie as near to the designated edge of the PrWd as possible.

• **Infixability.** In morphology proper (§4), a theory of infixation was developed from that of Prince and Smolensky (1991b, 1992, 1993) and McCarthy and Prince (1993), relying on the constraint Align(Affix, Stem), which characterizes ordinary prefixation or suffixation. This constraint on the alignment of one morphological category within another may be crucially dominated, and therefore violated, under the Prosodic-Morphological ranking schema **P** >> **M**. In attested cases of infixation, two types of crucially dominant **P**-constraints have been identified: purely prosodic cosntraints like ONSET and CODA, and constraints on the alignment of morphological constituents with prosodic ones, like Align(Root, PrWd) or the subcategorizational Align(Affix, Left, Foot, Right).

• **Prosody/Morphology Correspondence.** In the prosody/morphology interface (§5), various phonological consequences of morphological constituent-edges were attributed to just two constraints on the alignment of morphological constituents with prosodic ones, Align(Stem, Left, PrWd, Left), and Align(Stem, Right, Syllable, Right). The phenomena subsumed under this rubric include prohibited or required epenthesis at stem-edge, asymmetries in trans-junctural syllabification, and final consonant ‘‘extrametricality’’.

• **Prosodic Subcategorization.** Again in the prosody/morphology interface (§6), a complex pattern of the conditioning of augmentation follows from a subcategorizational alignment constraint, Align(Affix, Left, PrWd, Right).

The effects of Alignment, then, have been demonstrated in phonology, in morphology, and in their interaction.

Phenomena like these have received widely disparate treatment in previous work. The success of GA in unifying them is due in no small measure to the fact that all of these results were obtained with analyses embedded in OT. Two tenets of OT have played a central role throughout:

> • Constraints are ranked in a hierarchy of domination, and constraints are violated when crucially dominated. Virtually none of the Alignment constraints discussed reflects a phonotactic truth in the language at hand, and surely none is an absolute requirement conspicuously true in every language. Even in individual languages, they hold only contingently, in circumstances where no dominant constraint compels violation.
>
> • Constraints evaluate candidate output forms; they are indifferent to the process by which those candidates are generated. From a processual point of view, Alignment is expressed in incomprehensibly diverse ways. With processes out of the picture, as in OT, this diversity is not only tractable but expected, given the variety of ways in which Alignment can enter into crucial domination relations.

It is difficult to imagine how Alignment theory could be given a comparably general treatment without relying on these principles.

These, then, are the most significant empirical and theoretical claims argued here. Of course, an enterprise of this sort inevitably leads to predictions beyond the local problems addressed. It is obviously impossible to discuss them fully, but it is worthwhile to raise them as questions for future research.

GA predicts the existence of constraints of the form Align(PCat, GCat), where any instance of PCat must be aligned with the designated edge of GCat. Such constraints have several potential applications. With Align(Ft, Root) crucially dominated by PARSE-SYLL, the pattern obtained is directional foot-parsing, as in (31). Because this Alignment constraint mentions Root, rather than PrWd, it yields a quasi-cyclic pattern, in which the foot-parse is anchored on the root within the PrWd (*cf.* the case of Indonesian in Cohn and McCarthy in prep.). If Align(Ft, Root) is undominated, hence unviolated, then any foot must be aligned on the root — thus, stress will fall on a syllable of the root and nowhere else.

Within OT, an important issue disclosed in the course of empirical investigation was that of determining the **mode of violation** which a constraint submits to. In many cases, ALIGN — like EDGEMOST before it — determines degree or multiplicity of violation in terms of **distance** from the designated edge. In §5, however, we observed that in the application of ALIGN-RIGHT to Axininca augmentation, violation of the constraint must be observationally categorical (pass/fail) rather than gradient. We entertained the further refinement that in these cases violation was also gradient, but reckoned along a different dimension, counting substitution of a syllable edge for a PrWd edge as a violation superior to no alignment at all. This allows a uniform specification of the prosodic parameters in ALIGN-RIGHT and ALIGN-LEFT, with the differences in effect being attributed to constraint domination and minimal violation. The way is then opened for the theory of the prosody/morphology interface to be subtantively strengthened. These proposals involve many open questions, empirical and theoretical, which invite further exploration.

Finally, we must ask whether the various constructs of familiar phonological theory that are partly supplanted by GA can be dispensed with entirely. Prince and Smolensky (1993:§4) begin to address this question for **extrametricality**; McCarthy and Prince (1993:§7) likewise approach the issue for **prosodic circumscription**. The question is largely answered in §3 above and in McCarthy and Prince (1993:§A.2) for **directional iteration of foot-parsing**. Finally, alternatives to the **cycle**, addressed in §5 above, have received much attention in the literature (see the references in §2, among others). The emerging picture, then, is encouraging, though much remains to be done

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