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Realignment*

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Introduction

The notion "Alignment" entered Optimality Theory (OT) in the form of correspondence requirements that demand certain edges of grammatical constituents—say, the right edge of every stem—to coincide with a corresponding edge of a prosodic constituent—say, with the right edge of some syllable. Alignment requirements control the prosodic shape of morphological and other grammatical constituents and in this way lay the foundation for prosodic-morphological analysis. The constraint just mentioned forces the end of a stem to coincide with the end of a syllable: it must be syllabified, and the syllable must not span across a stem-suffix juncture. First proposed in Prince & Smolensky (1991, 1993) in the course of an analysis of the Australian language Lardil, this constraint was shown to be operative in Axininca Campa by McCarthy & Prince 1993a. In its concentration on the mapping relation between grammatical and prosodic categories, Alignment theory has its roots in earlier work on the syntax-prosody interface (most notably the 'end-based' theory of Selkirk 1986), extended to word-internal domains in Inkelas 1989 and Cohn 1989. The Alignment concept has since been developed in several ways. Thus it has been shown that significant analytical advantages can be obtained by extending Alignment to include an altogether different type of constraint linking two *prosodic* categories like prosodic words and feet: i.e., PCat-PCat constraints, in addition to the traditional GCat-PCat type. The internal prosody of words in Japanese is significantly shaped by the requirement that the left edge of every PrWd must correspond to the left edge of a foot (Itô & Mester 1992, 30, (42) "Left Edge Matching"). In different theoretical contexts, similar ideas have been explored in work by Burzio 1994 and Idsardi 1992. The most systematic and influential proposal in this direction is Generalized Alignment Theory (McCarthy & Prince 1993b), where Alignment is systematically developed into a large family of constraints requiring coincidence of (left or right) edges for a wide variety of categories. This work has opened up a rich field of alignment-theoretic analysis including, for example, directionality effects in footing. In fact, this line of research has demonstrated that Alignment constraints, even though logically independent of the central tenets of OT (viz., ranking and violability of constraints, with optimality defined as best-satisfaction), can only unfold their full analytical and explanatory potential within the ranking network of an optimality-theoretic grammar. By further developing an alignment-theoretic approach to syllable structure and extending it to issues relating to structural complexity and the sonority profile of syllables, this paper brings empirical and formal considerations to bear on the proper definition of the notion "alignment", presenting old problems and exploring new ideas along the way.

1. Syllable Theory and Alignment

Syllable wellformedness conditions of various kinds have played a significant role in the optimality-theoretic analysis that grew out of Prince and Smolensky's 1993 inaugurating work (henceforth P&S 93). In particular, the ranking of the two most basic wellformedness conditions— Onset (requiring/favoring the presence of onsets) and NoCoda (requiring/favoring the absence of codas)—with respect to Faithfulness constraints has been pivotal in numerous analyses.

(1) Basic Syllable Theory:

	Onset:	Syllables without onsets are disallowed.
	NoCoda:	Syllables with codas are disallowed.

Exploring the limits of alignment-theoretic statements, McCarthy & Prince 1993b (henceforth, M&P 93b) suggest that Onset and NoCoda can be formulated as requiring, respectively, that every syllable be left-aligned with a consonant (Onset) and right-aligned with a vowel (NoCoda).[1]

(2)	Onset:	Align-Left (σ,C)
	NoCoda:	Align-Right (σ,V)

As in all alignment constraints, the first argument is quantified universally ("every syllable"), the second existentially ("some consonant"). Generally speaking, one of the most fertile formal resources of Generalized Alignment Theory lies in the possibility of exchanging the two arguments, providing a rich network of related conditions with different logical force. For example, M&P 1993b show that great mileage can be obtained from the interplay of mirror-image constraint pairs like those in (2).[2]

(3) Align-Left (PrWd, Ft)

Align-Left (Ft, PrWd)

Regarding the alignment-theoretic versions of Onset and NoCoda (3), however, M&P (1993b, 20) state that such combinatorial freedom of argument settings is unavailable, remarking that "[h]ere G[eneralized] A[lignment] provides a way of formalizing the substantively-fixed constraints." Clarification and formalization are certainly significant achievements in themselves; it appears, however, to be premature to conclude that such combinatorial freedom of argument settings is unavailable for syllable theory[3]. As we will see, the internal richness and symmetry of the emerging alignment-theoretic syllable theory is considerably richer than a mere restatement of familiar conditions.

1.1 Syllable Alignment and Segment Alignment

The task before us, then, is to explore the formal and empirical content of the mirror-image (reversed argument) versions of Onset and NoCoda, given in (4).

(4) AlignLeft (σ, C) "Onset"

AlignLeft (C, σ) "Align-C" (mirror-image of Onset)

AlignRight (σ, V) "NoCoda"

AlignRight (V, σ) "Align-V" (mirror-image of NoCoda)

Reversing the arguments for Onset yields an alignment constraint (Align-C) which focusses on the consonant (formally, quantifies universally over consonantal segments), and requires it to be left-aligned with some syllable. Similarly, reversing the arguments for NoCoda results in an alignment constraint (Align-V) which focusses on the vowel, and requires it to be right-aligned with some syllable. The following chart organizes the mirror-image constraint pairs in terms of their arguments: We will refer to Onset and NoCoda, with the syllable as the first argument, as *syllable(-to-segment) alignment* constraints, and the mirror-image versions, with consonant/vowel as first argument, as *segment (-to-syllable) alignment* constraints.

(5)

	Alignment	
	of syllables: (σ,__)	of segments: (seg,__)
Left edge	(σ, C) "Onset"	(C,σ) "Align-C"
Right edge	(σ, V) "NoCoda"	(V,σ) "Align-V"

The syllable alignment constraints require every *syllable* to be left-aligned with a consonant (i.e., to have an onset) and to be right-aligned with a vowel (i.e., to be open). On the other hand, the mirror-image segment alignment constraints require every *segment* to be left/right-aligned with syllables: consonants must be syllable-initial, vowels must be syllable-final.

From a purely formal standpoint, it is obvious that the segment alignment constraints differ in logical force from the corresponding mirror-image syllable alignment constraints. More interesting, perhaps, is the fact, to be demonstrated below, that the new network of constraints yields a richer syllable typology, including systems with complex onsets, nuclei, and codas, bringing us one step closer to a serious approximation of the range of syllabification systems encountered in natural languages. For better or for worse, a characteristic feature of the new approach is its exclusively alignment-theoretic nature, without reliance on configuration-specific penalties like "CodaCond", "NoComplex", "NoLongVowel", "NoDiphthong" found in the literature (see P&S 93 and Rosenthall 1994, among others).

1.2 Align-C

Besides Onset and NoCoda, one of the most frequently discussed syllable structure conditions is the Coda Condition (Itô 1986, 1989, etc.), which restricts the *type* of consonant that can occupy the syllable-final position. As is well known, the Coda Condition (henceforth: "CodaCond", following P&S 93's usage) plays a pivotal role in accounting for the form and distribution of intervocalic clusters found in languages. In languages that allow codas at all, it restricts the type of consonants that can occupy this position. Typically, only unmarked elements (like coronal sonorants) and consonants homorganic (i.e. place-linked) to the following onset make licit codas. In Itô & Mester 1994, we argue that CodaCond is not a negative constraint disallowing certain syllable-final consonants, but is formally an Align-C constraint, requiring consonants to be left-aligned with syllables (6)—i.e. the mirror-image counterpart of Onset, in the sense of (4) and (5).

(6) CodaCond = Align-C (Itô & Mester 1994)

Align-Left (C,σ) $\forall$ C$\exists$σ [Coincide(Left-Edge-of (C),Left-Edge-of (σ))]

"For every consonant C, there is a syllable σ such that the left edge of C coincides with the left edge of σ."

This is the general form of CodaCond, ruling out all consonantal elements syllable-finally. The fact that (6) is a positive statement is not an idiosyncrasy; rather, it shares this property with all alignment statements in the current framework[4]. In concrete cases, the consonantal element referred to by means of "C" in (6) is often more narrowly circumscribed by referring to CPlace, marked CPlace, major segment types (resonants, obstruents), etc. (see below). In this way, CodaCond (6) is, properly speaking, an alignment scheme that in individual grammar is cashed in for some set of elementary alignment conditions.

In order to see how the alignment constraint in (6) can do the work of earlier statements of CodaCond, consider the following simple example. M&P (1993b) note that like many other Semitic languages, Bedouin Arabic and Biblical Hebrew have a constraint against pharyngeal codas, as a particular instantiation of CodaCond (McCarthy 1994). We reproduce their formulation below in (7), where "pharyngeal" refers exclusively to Cplace:

(7) CodaCond (Arabic, Hebrew): *[pharyngeal] $)_\sigma$ (M&P 1994, 44, (93))

In the theory advocated here, (7) is replaced by the Alignment Constraint (8).

(8) Align-Pharyngeal: Align-Left ([pharyngeal], σ)

Rather than disallowing pharyngeals in the coda, Align-Pharyngeal assigns a mark to any pharyngeal consonant not left-aligned with a syllable[5]. Just as in the original analysis, this constraint dominates Fill, resulting in epenthesis (indicated by '□' in (9)). The constraint interaction resulting in outputs like those in (9) is depicted in tableau (10).

(9) ya.ʕ□.mōd 'he will stand'

he.ħ□.zīq 'he strengthened'

(10)

	Align-Phar	Fill
.yaʕ.mōd.	*!	
☞ .ya.ʕ□.mōd.		*

The move towards stating CodaCond as a constraint left-aligning consonants with syllables is conceptually attractive because it turns CodaCond from an association condition loosely appended to the rest of syllable theory into a counterpart of alignment-theoretic Onset (see (4) and (5)).

1.3 Align-V

Having found a strong case for Align-C in the form of traditional CodaCond, it is a natural step to turn to Align-V (repeated in (11)) and ask whether any known syllable wellformedness condition might fall under it.

(11) Align-V AlignRight (V,σ)

The answer is not difficult to find: If the right edge of every vowel must coincide with a right syllable edge, this does not only mean that vowels should stand in open syllables, but also that *vowels should not be part of complex nuclei*. Consider in this context the ban against diphthongs in Rosenthall (1994).

(12) NoDiphthong (NoDiph): * σ (Rosenthall 1994, 27)

```
 σ
/ \
μ μ
| |
Vi Vj
```

According to Rosenthall 1994, this is an undominated constraint in Yoruba, responsible for alternations as in (13).[6]

(13) /bu+ata/ [bata] 'pour ground pepper'

/ra+ọgẹdẹ [rọgẹdẹ] 'buy bananas'

We propose that the formal expression of the ban against complex nuclei should be the alignment constraint Align-V (11). The tableau (14) (adapted from Rosenthall 1994, 67) illustrates how the correct empirical results are obtained.

(14)

Input: /bu+ata/		**Align-V** AlignRight(V,σ)	Onset AlignLeft (σ, C)	Parse
a.	.bua.ta.	*!		
b.	.bu.a.ta.		*!	
c. ☞	.b<u>a.ta.			*

The segment alignment constraint Align-V requires every vowel to be right-aligned with a syllable, hence in (14a) the vowel *u* violates this constraint, since it is not syllable-final. In (14b) all the vowels are indeed parsed syllable-finally, fulfilling Align-V, but now the medial syllable .*a*. violates the syllable alignment constraint Onset. Thus, (14c) is the winning candidate, violating the low-ranking Parse, and fulfilling both Align-V[7] and Onset.

The constraint NoDiphthong (12) specifically targets a *sequence* of vowels within the syllable domain. The success of the corresponding nonsequential alignment constraint raises the prospect of further reducing the need for construction-specific sequential constraints in phonological theory.

1.4 Further segment alignment effects

It would be a mistake to view this alignment-theoretic approach to syllable structure as merely a succinct restatement of familiar conditions like Onset, NoCoda, CodaCond, and NoDiphthong. There is a deeper symmetry organizing the syllable structure constraints, quite comparable to the foot-related constraints; and we will see that the segment alignment constraints have more far-reaching effects than what is covered by CodaCond or NoDiphthong.

We start with the chart in (15) showing some correlations between syllable and segment alignment constraints in systems where $_{\sigma}$[CVC] is the upper bound for syllable complexity. In (15a) and (15d), the four constraints ("Onset", "NoCoda", "Align-C", "Align-V") are all satisfied in *.CV.* and all violated in *.VC.* And in (15b) and (15c), Align-C and Align-V have the same marks as the NoCoda column.

(15)

		syllable alignment		segment alignment	
		Onset	NoCoda	Align-C	Align-V
		AlignLeft (σ, C)	AlignRight (σ,V)	AlignLeft (C,σ)	AlignRight (V,σ)
a.	.CV.	✓	✓	✓	✓
b.	.V.	*	✓	✓	✓
c.	.CVC.	✓	*	*	*
d.	.VC.	*	*	*	*

This correlation between NoCoda and the segment alignment constraints might seduce unwary readers into concluding that only one of the three constraints (NoCoda, Align-C and Align-V) is necessary in the system.[8] This conclusion, however, would be erroneous: The apparent marking correlation between NoCoda and the segment alignment constraints exists only at the simplest level of syllabic organization, where many distinctions have collapsed due to the absence of complex onsets, complex nuclei, and complex codas. The correlation breaks down once we look beyond the $_{\sigma}$[CVC] barrier, as shown in charts (16) and (17). The syllable types considered in (16) have various kinds of onsets and nuclei onsets, but are all open. Those in (17) add further complexities in their post-vocalic parts (codas, simple and complex).

(16) (complex) onset, (complex) nucleus, open:

		syllable alignment		segment alignment	
		Onset	NoCoda	Align-C	Align-V
		AlignLeft (σ, C)	AlignRight (σ,V)	AlignLeft (C,σ)	AlignRight (V,σ)
a.	.CV.	✓	✓	✓	✓
b.	.CCV.	✓	✓	*	✓
c.	.CVV.	✓	✓	✓	*
d.	.CCVV.	✓	✓	*	*

(17) (complex) onset, (complex) nucleus, (complex) coda:

		syllable alignment		segment alignment	
		Onset	NoCoda	Align-C	Align-V
		AlignLeft (σ, C)	AlignRight (σ,V)	AlignLeft (C,σ)	AlignRight (V,σ)
a.	.CVC.	✓	*	*	*
b.	.CVCC.	✓	*	**	*
c.	.CCVCC.	✓	*	***	*
d.	.CCCVCC.	✓	*	****	*
e.	.CVVC.	✓	*	*	**
f.	.CVVCC.	✓	*	**	**
g.	.CCVVCC.	✓	*	***	**

With respect to Onset and NoCoda, these two groups of syllable types incur the same marks (✓Onset, ✓NoCoda in (16), ✓Onset, *NoCoda in (17)). But they differ widely with respect to the segment alignment constraints, which focus on every consonant and every vowel in the phonological string. Thus a syllable with a complex onset *.CCV.* (16b) fulfills Onset, but the second C incurs one violation of Align-C. Similarly, a syllable with a complex nucleus (diphthong or long vowel) of the form *.CVV.* (16c) fulfills NoCoda, but the first V incurs one violation of Align-V. Note that violations of Align-C and Align-V in (16) and (17) can simply be measured categorically ("pass/fail"), without having to rely on the gradient measures of disalignment suggested by McCarthy & Prince 1993b for foot directionality effects. On the other hand, Mester & Padgett 1994 have found a potential use for gradient measures of violation (in terms of segmental or moraic distance) in syllable theory. We therefore leave the role of gradient violation in syllable alignment as an open question.

Multiple violation marks are incurred when several segments are independently evaluated by the constraint. For example, four consonants are evaluated by Align-C in (17c). The first one passes, the other three fail the alignment test, incurring three marks.

As far as Align-V is concerned, the requirement is not that every syllable should end in some vowel, but that every vowel[9] should end some syllable, and this requirement is violated by every diphthong and every long vowel. Similarly, Align-C is violated by every complex onset (as well as by codas, whether simple or complex (17)).

In terms of the relations between the individual constraints under discussion here, we find the picture in (18), which reveals the extent to which the four constraints are orthogonal to each other (the cells are filled with examples illustrating the compatibility of the two constraint evaluations). Disregarding heterosyllabic geminate consonants and syllables without nuclear vowels, there are two implications (the corresponding cells are marked "**no**" in (18)): A violation of NoCoda implies a violation of Align-C (*[NoCoda] ⊃ *[Align-C]) and also a violation of Align-V (*[NoCoda] ⊃ *[Align-V]).[10]

(18)

Onset	✓								
	*								
NoCoda	✓	.cv.	.v.						
	*	.cvc.	.vc.						
Align-C	✓	.cv.	.v.	.cv.	**no**				
	*	.ccv.	.vc.	.ccv.	.cvc.				
Align-V	✓	.cv.	.v.	.cv.	**no**	.cv.	.ccv.		
	*	.cvv.	.vv.	.cvv.	.cvc.	.cvv.	.vc.		
		✓	*	✓	*	✓	*	✓	*
		Onset		NoCoda		Align-C		Align-V	

The approach sketched above partially succeeds in deriving specific complexity facts from the interaction of general constraints and in this way achieves a deeper level of explanation than construction-specific constraints. As Scott Myers and an anonymous reviewer have reminded us, the alignment-theoretic approach is still programmatic and leaves open many questions in the area of syllable complexity, in particular the mutual independence of various factors: (i) onset complexity and coda complexity, (ii) long vowels and diphthongs, and (iii) nucleus complexity and the admission of closed syllables. Construction-specific constraints like NoComplex Nucl, NoLongVowel, NoDiphthong, NoComplexOns, NoCompexCoda, etc., will obviously remain unsurpassed in terms of data coverage, but must by the same token remain purely descriptive and do not bring us closer to a theoretical understanding of such complexity issues and their interrelations, with or without Optimality Theory.

In order to illustrate what is involved, consider the third point mentioned above: Some languages allow complex nuclei (long vowels and diphthongs), but no closed syllables. Other languages allow closed syllables, but no complex nuclei. Still other languages allow, or disallow, both. Consider now a language allowing codas but no complex nuclei: Since closed syllables violate both Align-C and Align-V, Align-V is clearly a violable constraint in such a language. But then, why would complex nuclei be excluded? One way of approaching this issue is to differentiate between Parse-C and Parse-V (as suggested in P&S 1993 and in many other studies). The reader can easily verify that the ranking (19a) derives a coda-language without complex nuclei, whereas (19b) derives a no-coda-language with complex nuclei.

(19) a.

Parse-C	
!	p
Align-V	Align-C
!	
Parse-V	

b.

Parse-V	
!	p
Align-V	Align-C
!	
Parse-C	

Whether or not such a faithfulness-based analysis is ultimately correct, it serves to illustrate the central strategy advocated here: Instead of postulating construction-specific complexity constraints, the generalizations are derived by having segment-alignment constraints interact with members of other constraints families in crucial ways.

1.5 Segment Alignment and Segment Sonority

A legitimate question to ask at this point concerns the role of segment alignment constraints in phonology, including its interface with phonetics: Why do segment alignment constraints exist? (Note that this question is different from: What service can they perform in the analysis of complex syllable structures?)[11] We hypothesize that segment alignment constraints are related to a more fundamental requirement: *Segments should be prominent*. And being leftmost or rightmost in some domain counts as being prominent. The reason why consonants should be *left*-aligned with syllables, and vowels *right*-aligned, lies probably in their phonetic nature, involving both articulatory and acoustic factors; formal phonology records the asymmetry in terms of alignment constraints whose edge-orientation is substantively determined.

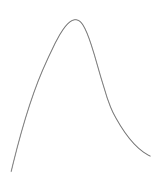
A syllable has only two edges, hence only two segments can be prominent in virtue of being adjacent to a syllable edge (*.CV.* violates no prominence constraints). This raises two intrisically related questions: What does the prominence profile of larger syllables (like *.trend.*) looks like? And what is the connection between the alignment-theoretic approach to syllable structure and classical (Sievers-Jespersen) sonority theory?[12]

Taking up an idea first brought up in Prince 1983 and to some extent developed in work by Borowsky 1984 and others, suppose we give formal expression to the sonority relations between segments by means of a sonority grid representation: the more sonorous a segment, the more grid marks in its sonority grid column (as Sharon Inkelas reminds us, a different but related idea is the syllable-internal metrical constituency hypothesized by Kiparsky 1979 and Zec 1988). This is shown in (20a), which corresponds to the familiar depiction of syllable sonority in (20b) (by means of an upwards-downwards curving graph). Since there is good reason to believe that the notion of sonority itself, while phonetically grounded, does not represent a directly measurable phonetic quantity, discrete grid representations might in fact be more appropriate than the largely fictitious continuity of sonority "profiles" like (20b).

(20) a.

```
      x
   x  x
   x  x  x
x  x  x  x  x
t  r  e  n  d
```

b.



t r e n d

At first glance, it looks as if grid representations as in (20a) serve only an illustrative purpose and should not be part of the representational system admitted by formal phonology. But things begin to look different when we consider the familiar sonority profile in this grid from the point of view of Alignment[13]. If being prominent means being foremost (leftmost, rightmost) in some domain, a segment can fulfill alignment with a syllable edge in two ways: (i) by literally occupying the edge position (*string alignment*—of the segment within the terminal string), and (ii) by occupying an edge position in terms of its highest sonority grid mark (*grid alignment*— of a segment's highest grid mark, on its level of the sonority grid). The idea is that every segment in a syllable like .*trend.* fulfills grid alignment, as indicated in (21): The highest (circled) grid mark in every segment column is adjacent to (aligned with) the syllable edge.

(21)

*			x			*
*		x	x			*
*		x	x	x		*
*	x	x	x	x	x	*
*						*
*	t	r	e	n	d	*

The optimality of culminative sonority profiles lies in the fact that *any* permutation of two adjacent grid columns in (21) would cut off the segment with a shorter grid column from the edge (by an intervening segment with a higher grid column). In (22), we show various reorderings of the nonce string [klurd] and their representations on the sonority grid. For clarity, we denote the highest grid mark of the sonority grid column associated with some segment k as k.[14]

(22)

a.

```
/)))))))))))))u) ))))))))))1
*              x    r  )))))1
/))))))))l     x    x       *
/)  k     x    x    x    d  )1

    k     l    u    r    d
```

b.

```
/))))))u)))))))))))))))))1
*      x    r ))))))))))1
*      x    x    l ))))))1
/)k    x    x    x    d )1

  k    u    r    l    d
```

c.

```
/))))))))))  u))))))))))))1
*            x    r ))))))1
/)l          x    x       *
* x   *k     x    x    d )1

 *l    k     u    r    d
```

d.

```
/)))))u))))))))))))))))))1
*     x          r )))))1
*     x   *l     x      *
/)k   x    x     x     d--1

 *k   u    l     r     d
```

What is of interest for grid alignment, then, is the topmost entry in each segment column. For a segment *s*, we will refer to the highest sonority mark in its grid as Max(*s*) (written as s). An alignment-theoretic version of the Sievers-Jespersen sonority sequencing principle then takes the form of a constraint requiring every segment *s* to be grid-aligned with a syllable edge.[15]

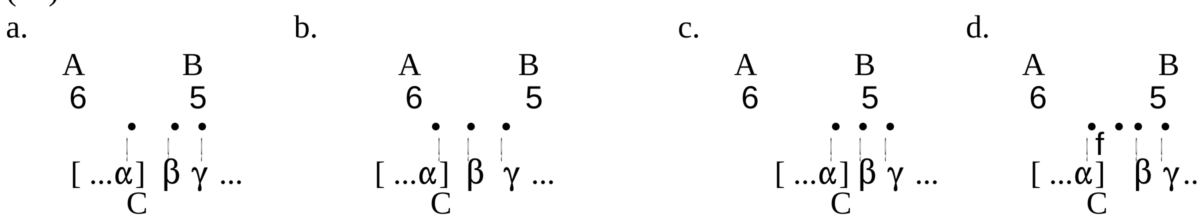
(23) Align-Edge (Max(s),σ) (where "Edge" stand for "Left or Right")[16]

Finally, this alignment approach to syllable sonority may provide a new formal foundation for the notion 'demisyllable' familiar from the work of Fujimura and Lovins 1977, Fujimura 1979, and Clements 1990: The initial demisyllable consists of the substring grid-aligned with the left edge of the syllable, while the final demisyllable consists of the substring grid-aligned with the right edge of the syllable. As seen in (22a,b), the peak vowel is aligned with both edges, and hence is a member of both the initial and final demisyllable.

2. Crisp Edges

What counts as aligned/misaligned becomes less straightforward when we consider junctures with multiple linking. In order to illustrate the problem, let us consider the four different situations in (24) with respect to Align-R constraints (both Align-R (A,C) and Align-R (C,A)). There is little doubt that (24a) should count as aligned and (24b,c) as misaligned. But how about (24d)? Here the rightmost element of C, α, is indeed linked to an element at the right edge of A—but not exclusively: α is also linked to an element at the left edge of B. It is such situations of nonexclusive linkage (in the terminology of Merchant 1996) that we turn to next.

(24)



We will first take a closer look at some past OT analyses that deal with such cases, and then consider the consequences for syllable-theoretic alignment constraints. As we will show, the double linking scenario provides access to details of alignment structure, and helps us settle an open question regarding the formal definition of alignment.

2.1 Nonexclusive Linking and the Lardil-Axininca Alignment Dilemma

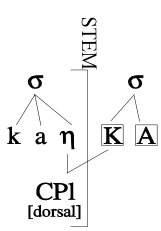
The two most influential syllable-based analyses in Optimality Theory, that of Lardil (P&S 1993) and of Axininca Campa (M&P 1993a), both employ the GCat-PCat alignment constraint Align-Right (25), requiring right stem edges to coincide with right syllable edges.

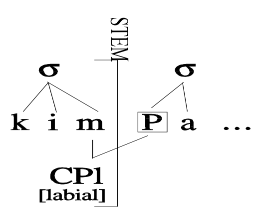
(25) Align-Right (stem, σ) See P&S 1993, 103 (Lardil), M&P 1993a, 35-36 (Axininca Campa)

An unresolved problem arises in situations where the crucial stem-suffix juncture is multiply linked: the interpretation of this alignment constraint diverges for Lardil and Axininca Campa. In order to capture the facts in the two languages, "Align-Right (stem,σ)" must be interpreted as **fulfilled** for the multiply-linked structure in Lardil (P&S 1993, 103), but as **violated** in the parallel Axininca Campa situation (M&P 1993a, 39-40).

(26) a. Lardil /kaŋ+a/ 'speech' b. Axininca Campa /kim+aanc^{h}i/ ‘to hear’

[.kaŋ.ka.], *[.ka.ŋa.] *[.kim.paan.c^{h}i.], **[.ki.maan.c^{h}i.]**





[.kaŋ.⌈Ka.] (aligned?) *[.kim.⌈Paan.c^{h}i.] (misaligned?)

In Lardil (26a), [.kaŋ.⌈Ka.] (where [K] denotes an epenthetic onset filler homorganic with the stem-final [ŋ]) is taken to satisfy alignment, and is for this reason preferred to the misaligned *[.ka.ŋ|a.] In Axininca Campa (26b), on the other hand, both the multiply-linked *[.kim.⌈Paan.c^{h}i.] (where [P] denotes an epenthetic onset filler homorganic with the stem-final [m]) and the nonepenthetic [.ki.m|aan.c^{h}i.]are taken as misaligned ("Align requires sharply-defined morpheme edges, but linking [...] undoes the desired relation between the morphological and prosodic constituency of a form" (M&P 1993a, 39-40)). Since the two competing candidates [.ki.m|aan.c^{h}i.] and [.kim.⌈Paan.c^{h}i.] tie on Align Right (violations are crucially reckoned categorically, not gradiently), Fill decides in favor of the first candidate (which gets by with less epenthesis).

The inconsistency in the interpretation of Alignment is illustrated in ranking tableau format in (27).[17] The correct results are obtained only if double-linking at the crucial juncture fulfills Align-Right for Lardil, but violates Align-Right for Axininca Campa.[18]

(27) a. Lardil:

/kaŋ + a/	Onset	Align-R	Fill
☞$_{\text{Lardil}}$ .kaŋ.⌈Ka.			*
.ka.ŋ|a.		*!	
.kaŋ.a.	*!		

b. Axininca

/kim + a.../	Onset	Align-R	Fill
.kim.⌠Pa.		*	*!
☞ Axininca .ki.m|a.		*	
.kim.a.	*!		

2.2 Alignment as Crisp Alignment

The formal definition of Alignment offered in M&P (1993b, 10, reproduced below in (28)) leads to the interpretation that is necessary for the Axininca analysis, where multiple-linking at the relevant juncture entails misalignment[19]. Formally, the sharp edge requirement is built into the definition of alignment reproduced in (28). The definition is cast in string-theoretic terms and makes use of the notion "*is a*" familiar from the formal theory of syntactic constituency (see section 2.3 below for further discussion of this notion).

(28) Dfn. Align(Cat1,Edge1,Cat2,Edge2) (M&P 1993b, 10)

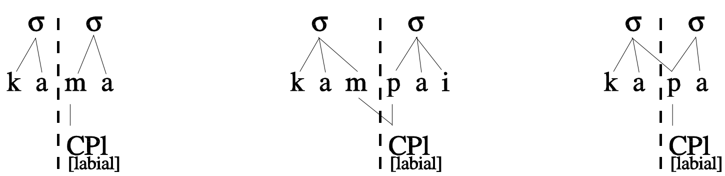
Let Edge1, Edge2 be either L or R. Let S be any string. Then, for any substring A of S that *is a* Cat1, there is [a] substring B of S that *is a* Cat2, such that there is a decomposition D(A) of A and a decomposition D(B) of B, both sub-decompositions of a decomposition D(S) of S, such that Edge1(D(A))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

The definition in (28) is one possible way of making the Alignment concept precise, among several alternatives; in particular, there is no a priori reason to make the definition so crucially dependent on the strict *is-a* relation. Before scrambling to find some reanalysis for Lardil that is compatible with (28), it would therefore be advisable to look at other alignment constraints and consider the consequences of the various ways of understanding Alignment. It turns out that the view of Alignment which interprets cross-linkage as misaligning is particularly problematic for the syllable-theoretic alignment constraints discussed above in section 1. Consider a situation where Align-C ("CodaCond") refers specifically to CPlace (29), as in Japanese, Ponapean, Diola Fogny, Axininca Campa, and many other languages.

(29)	a.	Align-C (Japanese, etc.):	Align-Left (CPlace,σ)
	b.	Onset:	Align-Left (σ,C)

As is well known, the central property of such cases is that multiply linked CPlace (linked to both coda and onset) does not count as a violation of CodaCond; earlier theories (starting with Itô 1986, 1989) take account of this by exempting geminate consonants and place-linked clusters in some way or other (by means of underlying placelessness persisting into the derivation, by linkage count, by licensing through Onset, or by other theoretical devices bestowing special privileges on geminates and partial geminates, see Goldsmith 1990, Lombardi 1991, Scobbie 1991, and Itô & Mester 1993 for discussion; see Itô, Mester, & Padgett 1995 for an approach to some aspects of feature linkage, feature (under)specification, and assimilation within OT). In a situation where CodaCond is a highly-ranked constraint, then, as in Japanese, geminates and place-linked clusters should not count as violating alignment. For example, just like the CPlace in (30a) fulfills alignment with the left edge of the second syllable, the CPlace in the linked cases (30b) and (30c) must also fulfill alignment with the left edge of the second syllable, in spite of the additional link to the preceding syllable.

(30) a. kama ‘kettle’ b. kampai ‘cheers’ c. kappa ‘water imp’



This alignment scenario is not restricted to CodaCond: All syllables in (30) clearly also fulfill Onset, irrespective of whether the targeted consonant is exclusively linked as a leftmost syllable daughter (30a) or whether it is *also* linked as the rightmost daughter of another syllable (30c). Fulfilling Onset by linking to an adjacent segment is quite common (e.g., leading to ambisyllabicity, see McCarthy 1993). These results cannot be obtained with the definition of Alignment in (28). In (30b,c), the two syllables share segmental material; therefore, in the technical sense of the relation *is-a*, neither (30b) nor (30c) contains a string that *is-a* syllable. It is hence impossible for Align-C ("CodaCond") (29a), as a condition seeking to align a consonant *to a syllable*, to be ever fulfilled in these forms. On the other hand, since there is no string that *is-a* syllable, Onset (29b) is vacuously fulfilled (in the absence of a string that *is-a* syllable, there can never be a string that *is-a* syllable and fails to be left-aligned with a consonant), irrespective of the absence or presence of onsets.

The foregoing discussion makes it clear that under the definition of Alignment in (28), our attempt to state basic syllable laws in terms of alignment constraints cannot succeed—we end up with absurd results (see Itô & Mester 1994 for further discussion). Note, however, that the culprit is not the notion "Alignment" by itself, but rather the idea that Alignment is built on the notion *is-a*, which is responsible for the crisp alignment requirement.

Like Align-R in Lardil, Onset and Align-C are constraints whose alignment requirements are fulfilled even when double linking has blurred the crucial edge. From this perspective, the "odd man out" is not the Lardil case, but rather the Axininca case (and the conception of Alignment on which it is built). Before throwing out the baby with the bathwater, however, we should also note the kernel of truth that remains in the thesis of crisp alignment: There is a penalty against cross-junctural linkages, as shown by the facts of the Axininca case.

Our conclusion is that the crisp edge requirement and the general notion “alignment” are independent elements of the theory that must be decoupled. In other words, we propose that alignment constraints are indeed fulfilled in noncrisp linkage situations.[20] Furthermore, there is a family of constraints favoring crisp edges of prosodic categories that we will refer to as “CrispEdge”). We develop the formal details in the next section, and show that CrispEdge is independent of the various alignment constraints in terms of its function and its ranking with respect to other constraints.

2.3 Alignment and Crisp Edges: Definitions and further issues

Allowing noncrisp linkage to fulfill alignment constraints requires only a small formal change in the definition of Alignment. The idea is to employ a relation which traces downwards from a category to the terminal string and finds the category's content. This relation will take the place of the *"is a"* relation which traces upwards from a terminal substring towards a category and requires uniqueness of the higher category, in the sense explained above (see (28) and the related discussion). We will make use of the relation *"is-the-content-of"* (identical with Pierrehumbert & Beckman's (1988, 156) notion "*substantive fringe of a node*"); for our purposes here, it will be sufficient to note that within a phonological representation a terminal substring A *is-the-content-of* a category $\mathfrak{C}$ if and only if A is the maximal terminal substring dominated by $\mathfrak{C}$. Note that a string A can *be-the-content-of* a category $\mathfrak{C}$ even if some element of A is also linked to some node outside of $\mathfrak{C}$.

In (31), we first introduce some notation designed to facilitate formal development.

(31) Notation:

| ... |	"the content of ..."	$\lvert\mathfrak{C}\rvert = /\beta/$	"the content of $\mathfrak{C}$ is the string β"
$\equiv$	"*is-a*"	$/\beta/ \equiv \mathfrak{C}$	"the string β *is-a* $\mathfrak{C}$"
$\subseteq$	"is a substring of"	$/xy/ \subseteq /wxyz/$	"the string *xy* is a substring of the string *wxyz*"

Consider next the example in (32).

(32) a. σ_1 σ_2

a t a *atta*

b. $|\sigma_2| = /ta/$

c. $/ta/ \not\equiv \sigma$

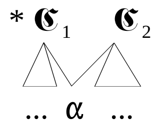
In (32a), /ta/ *is-the-content-of* σ_2 (32b): A trace downwards from σ_2 converges on /ta/ as the maximal terminal substring dominated by σ_2. On the other hand, /ta/ *is*-not-*a* σ (32c): A trace upwards from the terminal elements of /ta/ does not converge on a single node labelled "σ". We note without proof that $/x/ \equiv \mathfrak{C}$ implies $|\mathfrak{C}_i| = /x/$ (for some *i*), whereas the converse does not always hold. Equipped with this understanding of *is-the-content-of* ("|...|"), we can proceed to the revised definition of “Alignment” in (33) (built on (28), with the changes noted earlier).

(33) **Revised definition of Alignment**: Align ($\mathfrak{C}_1$,E_1,$\mathfrak{C}_2$,E_2)

Let E_1, E_2 be either Left or Right. Let S be any string. Then, for any $A \subseteq S$ with $A = |\mathfrak{C}_1|$, there is a $B \subseteq S$ with $B = |\mathfrak{C}_2|$, 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 $E_1(D(A)) = E_2(D(B))$.

Turning then to the CrispEdge constraint, its intuitive aim is to rule out any linking across the edges of prosodic categories, as depicted in (34).

(34) "Multiple linking between prosodic categories is prohibited":



(35) is a formal version of the CrispEdge constraint (or rather, constraint scheme); every prosodic category has an associated constraint of this kind, and the different CrispEdge constraints can be separately ranked.

(35) **CrispEdge[PCat]**

Dfn. Let /A/ be a terminal substring in a phonological representation, $\mathfrak{C}$ a category of type PCat, and /A/= $|\mathfrak{C}|$ (*the-content-of* $\mathfrak{C}$). Then $\mathfrak{C}$ is *crisp* (has *crisp edges*) if and only if A *is-a* $\mathfrak{C}$: $\forall A\ (/A/ = |\mathfrak{C}| \supset /A/ \equiv \mathfrak{C})$

CrispEdge[PCat]: A PCat has crisp edges.

CrispEdge remains to be further developed in terms of categories and L/R edges. Of central importance is CrispEdge[PrWd], which figures for example in the analysis of the Prosodic Morphology of Sino-Japanese by Itô & Mester 1996; if in most dialects of English (word-internal) ambisyllabicity is only possible in non-foot-initial position (see Kiparsky 1979, among others), this can be viewed as a consequence of CrispEdge[Ft]. CrispEdge[σ] rules out gemination and similar cases of double linking. In the version of the CrispEdge constraint in (35), there is no attempt to distinguish between left and right edges. If this turns out to be necessary, relativization to particular edges can be introduced (general notions like 'edge', 'left', and 'right' are not the exclusive property of Alignment Theory). An apparatus more complex than the one in (35) is certainly imaginable, for example, with crispness requirements coupled with particular alignment configurations, but would have to be supported by empirical evidence. Until such evidence emerges, the plain form in (35) seems adequate.

The independence of Alignment and CrispEdge is brought home in chart (36). We are here considering CrispEdge[σ] and Align-C (both binary constraints, i.e. evaluated categorically: pass/fail). (36a-d) are examples for all four marking combinations: (✓ ✓), (✓ *), (* ✓), and (* *).

(36)

	CrispEdge[σ]	AlignLeft (C,σ)
a. σ σ 1 1 C V C V	✓	✓
b. σ σ 7 ¦ CVC V	✓	*
c. σ σ 7 1 CV C V	*	✓
d. σ σ 7 7 CVCCV	*	*

2.4 Resolving the Dilemma

Once Alignment constraints and CrispEdge constraint are distinguished, the resolution of the Lardil-Axininca dilemma is straightforward: From the current perspective, the dilemma arose out of a notion of "Alignment" which was in reality a conflation of two separate notions. In the present theory, we can distinguish the two systems simply by ranking the relevant constraints differently for Axininca (CrispEdge » Align-R), and Lardil (Align-R » CrispEdge). The tableaux in (38) and (37) illustrate that the correct candidate is chosen as the winner (compare (26) and (27) above).

(37) Lardil:[21]

/kaŋ + a/	Onset	Align-R	CrispEdge(σ)	Fill
a. ☞ .kaŋ.⎾Ka.			*	*
b. .ka.ŋ|a.		*!		
c. .kaŋ|.a.	*!			

(38) Axininca:[22]

/kim + a.../	Onset	CrispEdge(σ)	Align-R	Fill
a. .kim.⎾Pa.		*!		*
b. ☞ .ki.m|a.			*	
c. .kim|.a.	*!			

Candidates with noncrisp linkages (38a and 37a) do not violate Align-R but violate CrispEdge. Axininca ranks CrispEdge above Align-R (38), hence the winning candidate has crisp-edged but misaligned syllables. On the other hand, the ranking of the two constraints are the reverse in Lardil (37), hence the winner has aligned but noncrisp-edged syllables.

3 Summary

This paper has pursued two independent but interrelated lines of inquiry into Alignment theory. First, it shows that a small extension of the theory results in the subsumption of a significant part of traditional syllable theory, including various conditions on syllable structural complexity (conditions on codas, complex onsets, complex nuclei, and complex codas), and it offers some speculations regarding an alignment-theoretic approach to classical sonority theory in terms of grid alignment. Second, the paper takes up a problem arising for the Alignment concept (as defined in McCarthy & Prince 1993b) in connection with the multiply linked structures that are the hallmark of modern nonlinear phonological representations. The central idea is that, different from the standard view, Alignment per se must be decoupled from the requirement that prosodic categories need sharp edges, not blurred by double linking. This requires a formal notion "CrispEdge" for prosodic categories and concomitantly a revised definition of Alignment.

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Notes

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[1] The formulation in M&P 1993b has four arguments: Onset "Align (σ,L,C,L)", and NoCoda "Align (σ,R,V,R)". We have extracted the same-edge argument here to simplify the discussion. The condensed notation also brings out the fact that alignment conditions (apart from the separate category of opposite-edge alignment conditions like "Suffix-to-PrWd" (M&P 1993a)) have two, and not four, arguments (see also Pierrehumbert 1993 for discussion).

[2] The first requires every prosodic word to have a foot flush with its beginning but is silent about other feet contained within a prosodic word. The second requires the left edge of every foot to coincide with the left edge of some prosodic word but does not require anything of prosodic words in general. The latter constraint incurs multiple violations in foot parsing; violations are reckoned in a gradient manner; selection proceeds under the criterion of minimum violation, as usual, and picks the foot parse most clustering towards the edge-to-be-aligned-to: every other parse incurs more alignment violations. (The idea that directionality effects can in this way be viewed as minimal violation effects is attributed to R. Kirchner in M&P 1993b.)

[3] This is not to say that substantively-fixed argument settings do not exist. As we will see

in section 1.5, the Edge-orientation (Left/Right) appears to be phonetically determined.

[4] Negative alignment statement are in principle not impossible: NonFinality (P&S 1993), for example, could be viewed as a negative constraint of this kind, i.e., as an antialignment constraint ruling out the right-alignment of any head of PrWd with PrWd: ~Align-Right ($\mathcal{H}$(PrWd), PrWd). This constraint (which calls for categorical and not gradient evaluation) makes use of "$\mathcal{H}$(PrWd)", a generalized notion of "head" denoting **any** head of PrWd, i.e. its immediate head (foot), the most prominent foot of the word, and in addition the head of the head foot, i.e. the most prominent syllable of the word, an idea first explored in P&S 1993: $\mathcal{H}$(X) = Head(X), Head(Head(X)), etc. Many questions regarding the proper treatment of nonfinality effects remain open, as demonstrated by Hung 1994; in a related vein, Spaelti 1993 proposes a WeakEdge constraint that favors sparseness of structure at right edges of prosodic trees, and obtains some interesting results that are not directly replicable with standard versions of NonFinality. In the present context, questions regarding the existence of antialignment constraints must remain unexplored, and we will confine our discussion to positive alignment statements.

[5] In this case, double-linking issues do not arise in connection with Align-Phar because of a high-ranking constraint against geminate pharyngeals (see McCarthy 1986, 1994). We will return to the important question of multiple linking in connection with our discussion of crisp and noncrisp alignment in section 2.

[6] Doug Pulleyblank (electronic communication, Feb. 16, 1995) has pointed out to us that the Yoruba facts are more complex than what is portrayed in (13), with grammatical conditioning, optionality, and other conditions entering as independent factors.

[7] Note that unparsed segments must count as vacuously fulfilling the segment alignment constraint.

[8] Thus it has been suggested to us in comments on our previous work on Align-C (Itô & Mester 1994) that Align-C takes the place of NoCoda, making the latter superfluous.

[9] Or "vowel mora". For simplicity of presentation, our segmental representations here abstract away from the more sophisticated representational apparatus in the current literature.

[10] Heterosyllabic geminate consonants violate NoCoda, but do not violate Align-C, under our conception of (noncrisp) alignment, see section 2. And a syllable without any vowel cannot violate Align-V, even if it violates NoCoda.

[11] See Itô & Mester (1994, 32-33) and in particular Smolensky 1995 for potential extensions in the area of onset maximization, syllable contact, and minimal sonority distance.

[12] See Sievers 1881 and Jespersen 1904; see also Saussure 1916 for a closely related aperture-based approach; among the numerous developments in contemporary phonology, see Zec 1988 and Clements 1990 and references therein.The latter work also contains a clear statement of the assumption that sonority in the sense relevant for syllable theory is not a single phonetic parameter which could be directly measured, but rather a composite phonological notion based on several different phonetic parameters, an assumption explicitly or implicitly made by most modern work on the topic; see Ladefoged 1990 for a concurrent view, from a phonetic perspective.

[13] This idea was suggested to us by A. Prince (electronic communication, April 21, 1994).

[14] Not all permutations that fulfill grid alignment (and thus conform to universal sonority

sequencing) are wellformed (e.g. *[klrud]). Clearly, further constraints are at work (e.g. demisyllabic constraints) whose nature and role remain to be investigated within the current framework.

[15] Grid Column Continuity (Liberman & Prince 1977, Prince 1983, Hayes 1995) would make it possible to state the constraint in a looser way, such that, for every segment, *some* grid mark in its grid column must be aligned with the syllable, without requiring the grid mark to be the topmost one in its column. Given grid column continuity, edge-adjacency of some non-maximal grid mark *g* entails edge-adjacency of all grid marks above *g*.

[16] In each case, Max(s) will occupy some level *L* of the grid. We assume here, postponing formal development for another occasion, that evaluating the alignment of Max(s) with a syllable σ means evaluating its alignment with the string of grid marks associated with σ at level *L*.

[17] In order to focus on the point under discussion, we treat the epenthetic final /a/ in Lardil (forced by prosodic word minimality, see P&S 93, ch. 7 and reference cited there) as a suffix. (We note that another possible attack on the Lardil/Axininca dilemma, different from the one pursued in the text, could focus on precisely this difference between the two cases: In Lardil, the input contains no suffixal material, and the free play of Gen results in the epenthesis of a whole syllable in many cases. In Axininca, on the other hand, the input already comes with a (vowel-initial) suffix. This raises the possibility that the emergence of an epenthetic onset filler in Lardil could be viewed as an instance of the emergence of the unmarked (here: syllable with an onset), in the sense of M&P 1994. It is not entirely clear, however, how this idea could be formally executed; furthermore, a full analysis of Lardil would have to take into account a number of allomorphy facts relevant for stem alignment, such as Hale's (1973, 423) observation

that the future suffix /-uŗ/ appears as /-kuŗ/ after all nasal-final stems (perhaps a case of prosodically controlled allomorph selection, in the sense of Mester 1994).)

[18] It is not possible to resolve the paradox by reranking Fill over Align-R in Axininca: As shown by M&P (1993a, 36) Align-R must dominate Fill: /iN + koma + i/ → .iŋ.koma|.Ti. , *.iŋ.koma|i. ‘he will paddle’.

[19] This 'thesis of crisp alignment' is further articulated in M&P (1993b, note 44), which reinforces the impression—with some reservations—that unique graph-theoretic mothering is indeed a precondition for successful alignment. See also McCarthy 1993 for an English example.

[20] Independent arguments in support of this can be found in other recent studies. Merchant 1996 shows that ambisyllabic consonants in German fulfill a constraint requiring stem-syllable alignment at right edges. Cohn & McCarthy (1994, 46) make a similar point, viz., that Indonesian vocoids linked simultaneously to nucleus and onset position do not count as violating root-to-foot alignment.

[21] Further aspects of the analysis of Lardil stem alignment (in particular, the emergence of unmarked homorganicity over coronality) are discussed in Itô & Mester (1994, 39-43).

[22] Another possibility is to make Align-R and CrispEdge(σ) crucially unranked in Axininca (which would require weaking the standard theory of constraint ranking, as noted at various points in P&S 93). Then the two constraints would tie, and lower-ranked Fill would cast the decisive vote in favor of *kima*.... (thus replicating an aspect of M&P's 1993a analysis).