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Reflections on CodaCond and Alignment

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1 Introduction

This note deals with the substance and formal nature of the Coda Condition within current Optimality Theory (Prince & Smolensky 1993; henceforth, P&S 1993), making use of the concept of Alignment in the generalized form developed in McCarthy & Prince 1993b (henceforth, M&P 1993b). In current Syllable Theory, the Coda Condition (henceforth CodaCond) plays a pivotal role in accounting for the form and distribution of intervocalic clusters found in natural languages. As is well known, in languages that allow codas at all, CodaCond 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. Thoroughly investigated cases illustrating coda conditions of various degrees of strength include Axininca Campa (Black 1991, Spring 1990), Diola Fogny (Steriade 1982), Italian, Ponapean (Itô 1986), Japanese (Yip 1991, 68-70) Lardil (Wilkinson 1988), Selayarese (Goldsmith 1990, 131-133), and English (level-I syllabification, see Borowsky 1986 and Myers 1987).

Even though CodaCond continues to play a prominent descriptive role in optimality-theoretic work, central questions regarding its theoretical status remain to be addressed—in particular, its relation to basic syllabic wellformedness principles requiring/favoring the presence of onsets and the absence of codas (in OT known as Onset and NoCoda). The following juxtaposition of the core content of the three conditions illustrates how closely the association constraint CodaCond is related to both Onset and NoCoda.

(1)	Onset:	Onsetless syllables are disallowed.
	NoCoda:	Codas are disallowed.
	CodaCond:	Codas are disallowed unless linked to a following onset.

This note grew out of discussions regarding Alignment in our phonology seminars at UMass, Amherst (Ling751/Fall 93) and UC Santa Cruz (Ling 219/Fall 93 and Ling212/Winter 94), and we are grateful to the participants, in particular, to Jill Beckman, Laura Benua, Zvi Gilbert, Amalia Gnanadesikan, Jason Merchant, Philip Spaelti, Su Urbanczyk, Rachel Walker, Laura Walsh, and Cheryl Zoll. We were also able to benefit from discussions with John Kingston, Jaye Padgett, Lisa Selkirk, and Paul Smolensky, and we would like to acknowledge the contributions of John McCarthy and Alan Prince at various points.

Consider the input /CVCV/ in (2), and compare the candidate output syllabifications (2a) and (2b). (2a) fulfills all three constraints, whereas (2b) violates all three of them:

(2) Input: / C_1VC_2V /; Output candidates:

	a.		b.	
	σ_1	σ_2	σ_1	σ_2
	/ |	/ |	/ | \	|
	C_1V	C_2V	C_1VC_2	V

C_2 in (2b), as coda to the first syllable, violates NoCoda. Secondly, the very fact that C_2 is syllabified as a coda to the first syllable deprives the second syllable of an onset, leading to a violation of Onset. And finally, since the following syllable has no onset, the coda consonant C_2 is not linked to an onset and hence violates CodaCond.

These rather straightforward observations, in their general direction familiar from other recent work in syllable theory (see in particular Clements 1990), reveal the significant redundancy inherent in the three central syllable wellformedness conditions, an indication that we are still dealing with empirical generalizations and not with genuine principles of theoretical phonology. It is true that each condition makes its own specific contribution in certain situations, but this is cold comfort, and only makes the problem a nontrivial one. It turns out that the usual reductionist strategy holds little promise in this case: That is, the idea of directly collapsing the three principles into one or even into two is not possible, since they are all ranked separately in well-supported optimality-theoretic analyses. In Lardil (3a), we find NoCoda ranked below both CodaCond and Onset (P&S 1993, 116) because of crucially intervening constraints; in Axininca Campa (3b), CodaCond is ranked above Onset (M&P 1993a, 93); and Berber (3c) echoes Lardil in ranking Onset higher than NoCoda (P&S 1993, 167).[1]

(3)	a.	Lardil:	CodaCond	>> α >>	NoCoda
			Onset	>> β >>	NoCoda
	b.	Axininca Campa:	CodaCond	>> γ >>	Onset
	c.	Berber:	Onset	>> δ >>	NoCoda

The overall factorial typology over the three constraints predicts the panorama of possible syllabification systems in (4). By focussing only on the skeleton of syllable structure constraints, i.e., by abstracting away from intervening faithfulness and alignment constraints, the table again brings out the overlap between the syllable-related constraints. In particular, the indeterminacy of analysis for each of the three languages might be considered problematic. At the same time, if the general promise behind the typology in (4) holds up and can be empirically substantiated, a powerful argument emerges for a theory allowing differential ranking of all three constraints, and hence for their individuation.

[1] In (3) 'α' etc. denote a sequence of intervening constraints typically including a faithfulness constraint (Parse, Fill) or an alignment constraint. Note that In M&P's 1993a analysis of Axininca Campa, NoCoda is low-ranking and plays only a marginal role; conversely, the ranking of CodaCond is not dealt with in the analysis of Berber syllabification, see P&S (1993, 12).

(4)

a.	ONSET	>>α >>	NO CODA	>>β >>	CODA COND	Berber?
b.	ONSET	>>α >>	CODA COND	>>β >>	NO CODA	Berber? Lardil?
c.	CODA COND	>>α >>	ONSET	>>β >>	NO CODA	Berber? Lardil? Axininca Campa?
d.	CODA COND	>>α >>	NO CODA	>>β >>	ONSET	Axininca Campa?
e.	NO CODA	>>α >>	CODA COND	>>β >>	ONSET	??
g.	NO CODA	>>α >>	ONSET	>>β >>	CODA COND	??

The task, then, is to bring out the relationships in a nonreductionist way, i.e. not by reducing the three constraints to a single one. It is in this area that Optimality Theory excels. The crucial idea is that of a constraint family (P&S 1993): a group of similar and related constraints all built around a single broad concept (e.g. Faithfulness; Sonority) but separately rankable in individual grammars. As P&S 1993 show, some families, like the sonority constraints, always preserve the intrinsic ranking relations between their members while allowing other constraints to intervene. These exhibit external, but not internal, factorial-typological freedom; other families, like the Faithfulness family, allow richer (and perhaps full) factorial-typological freedom, both externally (with respect to other constraints) and internally (among the members of the constraint family). These differences relate to substantive issues to be dealt with by theoretical phonology; what matters in the present context is the general notion that constraint families show dispersion behavior in terms of ranking (see Itô, Mester, and Padgett to appear for further argumentation and exemplification).

2 SyllSeg Alignment and SegSyll Alignment

Our goal here is to bring the notion of a dispersed constraint family to bear on Onset, NoCoda, and CodaCond and their relations; as we will see, Alignment Theory is indispensable for this project to succeed. Exploring the limits of alignment-theoretic statements, M&P 1993b suggest that Onset and NoCoda can be considered as Alignment Conditions, with Onset requiring every syllable to be left-aligned with a consonant, and NoCoda requiring every syllable to be right-aligned with a vowel.

(5) Onset: Align (σ,L,C,L)
NoCoda: Align (σ,R,V,R)

From now on, we factor out the common edge argument in such same-edge alignment constraints; in such abbreviated notation, Onset and NoCoda read as in (6). As in all alignment conditions, the first argument is universally quantified ("every syllable"), the second argument existentially quantified ("some consonant"). The condensed notation also brings out the fact that alignment conditions (except for the separate category of opposite-edge alignment conditions like "Suffix-to-PrWd", see McCarthy and Prince 1993a) have two, and not four, arguments (see Pierrehumbert 1993 for discussion).

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

One of the most interesting formal resources of Alignment Theory (M&P 1993b) lies in the fact that, at least formally, the two arguments can be exchanged, giving rise to a rich network of related conditions differing in logical force. For example, M&P 1993b show that great mileage can be obtained from the interplay of mirror-image constraint pairs like Align-Left (PrWd, Ft) and Align-Left (Ft,PrWd). 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 is silent about 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, and thus derives directionality effects (an idea attributed to R. Kirchner in M&P 1993b; see also Mester & Padgett 1994 for directionality effects in syllabification).

Regarding the alignment-theoretic versions of Onset and NoCoda, M&P (1993b, 20) remark: "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." Taken literally, this would mean that the contribution of Alignment Theory to our understanding of the basic laws of syllabification and their interrelations is limited to a clarificatory role. Clarification is a significant result in itself; but is seems imperative to push further at this point, and to explore the possibility that Alignment Theory might be able to make a more fundamental contribution in this area.

Since Itô 1986, CodaCond has usually been conceived of as a negative condition ruling out a particular configuration syllable-finally. One version is given below in (7): All consonantal place is ruled out syllable-finally (or: remains unlicensed, etc., see Goldsmith 1990, Lombardi 1991, Scobbie 1991, and Itô & Mester 1993a for different versions of such licensing approaches).

(7) $* \; C\,]_{\sigma}$ (Itô 1989, 224)
$\quad\;\; |$
$\;\; \text{Place}$

The step beyond this line of work, we argue, is to turn the tables around and to move away from a negative condition which rules out (or declares "unlicensed", "weakly licensed", "unsafe", etc.) consonantal place in coda position; let us consider the possibility that the correct formulation does not even mention the term "coda", and in fact does not refer to syllable-final position at all. Instead CodaCond is an alignment statement requiring consonantal place to occupy the *left* periphery of syllables. More precisely, CodaCond is the Alignment Constraint (8), requiring consonants to be left-aligned with a syllable. The fact that (8) is a positive statement is no idiosyncrasy; rather, it shares this property with all alignment statements in the current framework[2].

(8) **CodaCond:** Align-Left (C,σ)

This is the general form of CodaCond, ruling out all consonantal elements syllable-finally. Like M&P (1993b) in their alignment-theoretic version of Onset and NoCoda (see (5) above), we are using the C/V notation as a shorthand reference to the familiar bifurcation into the major segment types "consonant" and "vowel" (and not as skeleton slots). We assume without argument that every theory of segment-internal structure is in some form able to make this distinction, for example, by referring to aperture structure, to [±consonantal] specifications, to root nodes dominating c/v-place, etc. (see Kenstowicz (1994, 451-506) and
Clements & Hume to appear for recent overviews). In concrete cases, the consonantal element referred to by means of "C" in (8) is often more narrowly circumscribed by referring to CPlace, marked CPlace, major segment types (resonants, obstruents), etc. (see below). In this way, CodaCond (8) is, properly speaking, an alignment scheme that in individual grammars is cashed in for some set of elementary alignment conditions.

The move towards stating CodaCond as a constraint left-aligning consonants with syllables (9a) 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 (repeated in (9b) for comparison).

(9) a. **CodaCond:** Align-Left (C,σ)
b. **Onset:** Align-Left (σ,C)

It is now possible to perceive a deeper symmetry organizing the syllable structure constraints, quite comparable to the corresponding groups of foot-related constraints: as an

[2] This is not to say that negative alignment statement are in principle impossible: NonFinality (P&S 1993), for example, could be viewed as a negative constraint of this kind, i.e., as an antialignment constraint (i) ruling out the right-alignment of any head of PrWd with PrWd:

(i) NonFinality as Anti-Alignment: ~Align-Right ($\mathcal{H}$(PrWd), PrWd)

(i), which calls for categorical and not gradient evaluation, employs a notation used in Itô & Mester (to appear), where "$\mathcal{H}$(PrWd)" is 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. More generally, $\mathcal{H}$(X) = Head(X), Head(Head(X)), etc. Many open questions regarding the proper treatment of nonfinality effects remain, as demonstrated by Hung (1993); in a related vein, Spaelti (1993) proposes a general constraint WeakEdge 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.

upwards-aligning constraint, CodaCond (9a) is a member of the *Segment-to-Syllable-Alignment* family of constraints (henceforth, the "SegSyll" family); as a downwards-aligning constraint, Onset (9b) is a member of the *Syllable-to-Segment-Alignment* family of constraints (henceforth, the "SyllSeg" family). This rapprochement between Onset and CodaCond seems sufficient to warrant further exploration of the approach.

3 An illustration: Align [pharyngeal]

In order to see in more detail how the constraint in (9a) 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. We reproduce their formulation in (10). In the theory advocated here, (10) is replaced by the Alignment Constraint (11).

(10) CodaCond (Arabic, Hebrew): *[pharyngeal] $)_\sigma$ (M&P 1993b, 44, (93))
(11) 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[3]. Just as in the original analysis, this constraint dominates Fill, resulting in epenthesis (indicated by '□' in (12)). The constraint interaction resulting in outputs like those in (12) is depicted in tableau (13).

(12) ya.ʕ□.mōd 'he will stand'
he.ħ□.zīq 'he strengthened'

(13)

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

4 Syllable Contact and Onset Maximization

In languages that allow syllables to have complex onsets and codas (such as English), it is commonly (though not always) the case that a sequence like /atri/ is syllabified as *.a.tri.*, whereas a sequence like /arti/ is always syllabified as *.ar.ti.* Such onset maximization and syllable contact phenomena have occupied syllable theorists since the work of Kuryłowicz 1948, Vennemann 1972, and Kahn 1976. In the present theory, onset maximization as in our

3 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, to appear). We will return to the important question of multiple linking in connection with our discussion of "crisp" and "noncrisp" alignment below.

schematic example *.a.tri.* vs. *.ar.ti.* (i.e., always obeying sonority sequencing) follows from the interaction of two separate segment-to-syllable alignment constraints: an alignment requirement on obstruents (14a) and an alignment requirement on resonant consonants (14b).

(14) SegSyll Alignment:
- a. Align-Left (T,σ) "T (=obstruents) are syllable-initial."
- b. Align-Left (R,σ) "R (=resonant consonants) are syllable-initial."
- c. Ranking: Align Left (T,σ) >> Align Left (R,σ)

The ranking of the various segment-to-syllable alignment constraints with respect to each other is intrinsic and determined by the sonority hierarchy, as in the case of the 'margin/peak' association hierarchies of P&S 1993. With the universal ranking in (14c), onset maximization effects are predicted in the right cases (15a vs. b).

(15)

a. Input:	/atri/	Align(T,σ)	Align(R,σ)
i. ☞	.a.tri.		t
ii.	.at.ri.	a!	

b. Input:	/arti/	Align(T,σ)	Align(R,σ)
i.	.a.rti.	r!	
ii.☞	.ar.ti.		a

In grammars where NoComplex (the constraint ruling out complex onsets in P&S 1993) is ranked above the alignment constraints (14), the alignment constraints cannot result in different syllabifications like *.a.tri.* vs. *.ar.ti.* since the complex onset option is ruled out by the higher-ranking constraint NoComplex. Both clusters will always be split between two syllables, resulting in *.at.ri.* and *.ar.ti.*

(16)

		NoComplex	Align(T,σ)	Align(R,σ)
i.	.a.tri.	*!		*
ii.☞	.at.ri.		*	

Many further details regarding sonority sequencing in alignment-based syllable theory remain to be worked out and must be left for future investigations.

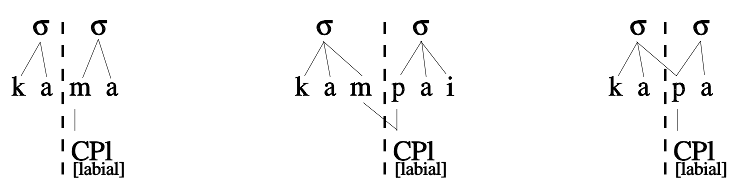
5 Alignment at Noncrisp Edges

Since the advent of autosegemental phonology, one of the hallmarks of nonlinear feature representations has been the fact that a single segment or a subsegmental unit of segment structure can be affiliated with more than one prosodic position. It is not surprising that the question of whether two categories are aligned becomes more intricate in such cases of multiple linking. Consider a situation where CodaCond refers specifically to CPlace (17), as in Japanese, Ponapean, Diola Fogny, Axininca Campa, and many other languages.

(17) CodaCond (Japanese, etc.): Align-Left (CPlace, σ)

As is well known, the central property of such cases of CodaCond is that multiply linked CPlace does not count as a violation; all earlier versions of CodaCond, beginning with Itô 1986, take account of this by exempting geminate consonants and place-linked clusters is some way or other (by means of underlying placelessness persisting into the derivation, linkage count, licensing through Onset, or other theoretical devices bestowing privileges on geminates and partial geminates, see Goldsmith 1990 and Itô & Mester 1993a for discussion). In a situation where CodaCond is a highly-ranked constraint, then, as in Japanese, geminates and place-linked clusters must not count as violating alignment: Just as the CPlace in (18a) fulfills alignment with the left edge of the second syllable, the CPlace in the linked cases (18b) and (18c) must also fulfill alignment with the left edge of the second syllable, in spite of the additional link to the preceding syllable.

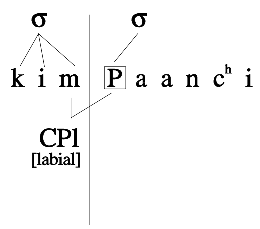
(18) a. kama 'kettle' b. kampai 'cheers' c. kappa 'water imp'



This alignment scenario is not restricted to CodaCond: All syllables in (18) must count as fulfilling the alignment-theoretic Onset constraint, irrespective of whether the targetted consonant is exclusively linked as a leftmost syllable daughter (18a) ("crisp alignment") or whether it is also linked as the rightmost daughter of another syllable ("noncrisp alignment") (18c).

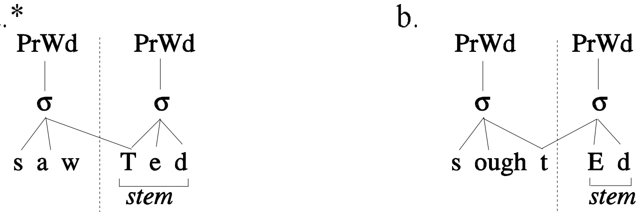
All of this sounds straightforward and hardly worth mentioning, when viewed from the perspective of past syllable-theoretic work related to CodaCond behavior. Somewhat surprisingly, this result has become problematic within Generalized Alignment Theory (M&P 1993b). As we will show, the double linking scenario can provide access to details of alignment structure, and help us settle an open question regarding the formal definition of alignment. We have just seen that syllabic alignment constraints (both of the SegSyll and of the SyllSeg family) must count as fulfilled, and not violated, in multiple linking situations (18). In very similar circumstances, however, GCat-to-PCat alignment constraints (dealing with the syntax /phonology interface) have been argued to be violated precisely *because of* multiple linking. For example, M&P (1993a, 39-40) argue that in Axininca Campa multiple place-linking in a case like (19) leads to a failure of alignment with respect to the constraint Align-Right (stem,σ). This constraint requires right stem edges to coincide with right syllable edges ("Align requires sharply-defined morpheme edges, but linking [...] undoes the desired relation between the morphological and prosodic constituency of a form.") This is taken as the reason why the form in question comes out as *.ki.maan.c^{h}i.* instead of **.kimpaan.c^{h}i.*: Both violate Align-Right, and the former wins because it does not have a Fill violation.

(19)



In a similar way, Align-Left (Stem, PrWd) is viewed as violated by ambisyllabic linkage at word boundaries in English (M&P 1993b, 48-49, McCarthy 1993a). Referring to the impossibility of ambisyllabic /t/ in "saw Ted" [sɔ:tʰɛd] (20a) (and hence obligatory aspiration, and no flapping, following Kahn 1976) as opposed to "sought Ed" [sɔ:ɾɛd] (20b), where ambisyllabicity (and hence flapping) is possible, M&P (1993b, 48-49) remark: "When the stem is consonant-initial [...], Align-Left [...] comes into play, *demanding a sharp coincidence of stem-edge with PrWd-edge. It is violated whenever a stem-initial consonant is (also) parsed by a different PrWd.* Thus, it rejects the ambisyllabic parse in /V⁻C/ juncture [...]" [Italics ours, JI/AM].

(20) a.* b.



(20b) is misaligned as well, but is selected as the best candidate because the higher-ranking Onset constraint prefers a filled onset position, in spite of the alignment violation.

The "thesis of crisp alignment" is further articulated in footnote 44, where unique graphtheoretic mothering is made a precondition for successful alignment. Formally, the sharp edge requirement is built into the definition of alignment reproduced in (21), which is cast in string-theoretic terms and makes use of the notion *"is a"* familiar from the formal theory of syntactic constituency, as can be seen in (21).

(21) 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)).

Suppose that substring A *is a* stem, but there is no suitable substring B that *is a* PrWd, in the sense that it constitutes a single PrWd and no part of it is traceable to anything outside of that PrWd: in that case Align-L(stem, PrWd) is violated, as in example (20a).

We are thus confronted with opposite demands simultaneously placed on the notion of alignment. On the one hand, there are the SyllSeg and SegSyll alignment constraints (Onset, NoCoda, CodaCond) that crucially must **not** require crisp edges. On the other hand, there are Gcat-to-PCat alignment constraints— part of the syntax-phonology mapping, in the theory developed by M&P (1993a, 1993b)— that appear to require crisp edges (but see the analysis of Lardil below). The tension between the two ways of assessing noncrisp linkage is already apparent in M&P (1993b, 48): Within the same tableau where the mislinked candidate (20a) is taken to task for violating Align-Left (stem, PrWd), no Onset violation is registered. In other words, mislinked /t/ qua stem-initial /t/ is penalized, but mislinked /t/ qua syllable-initial /t/ is not.

Astute and formally minded readers will no doubt point out that considerations of vacuous constraint satisfaction enters the picture here. Under the current definition reproduced in (21), alignment-theoretic Onset is indeed vacuously satisfied in (20a) because the string "Ted" *is not a* syllable (implications with a false antecedent are true). However, further reflection reveals a serious problem with this path into vacuity—instead of leading to the desired solution, vacuous satisfaction constitutes a problem for the definition of alignment in (21). Consider the substring "old" in the phrase "old Ed", structured parallel to (20b), i.e. with ambisyllabic /d/: [oʊlɾɛd] (we are abstracting away here from the word-initial glottal attack appearing in the phonetic implementation). It is patently absurd to claim that "old" suddenly starts fulfilling the Onset constraint just because its last consonant is doubly linked within the whole phrase. But this is precisely the unfortunate result we are left with under the definition of Alignment in (21): In "old Ed", there does not exist a string "old" that is an onset-violating syllable simply because there is no string "old" that *is a* syllable— the string "ol" is less than a whole syllable, and the string "old" is dominated by more than one syllable. The Onset constraint here is just an example, similar incorrect results are obtained for NoCoda, with linking of onset consonants inducing vacuous satisfaction of NoCoda, etc.

Such results are clearly unintended and unwelcome side effects pointing to some flaw in the formal notion defined in (21).There are numerous ways of approaching these problems, and this short note on CodaCond is not the place to pursue the issue and its ramifications. One possibility would be to focus on the typology of alignment constraints; for example, one might argue that GCat-PCat constraints do not tolerate cross-linkage, whereas other alignment constraints are indifferent in this respect. If this were indeed so, it would make sense to look for a formal (or functional) basis for such a distinction. However, such a categorization does not stand up to empirical scrutiny. Examples of GCat-to-PCat alignment constraints that tolerate noncrisp linkage include Lardil (see below) and German

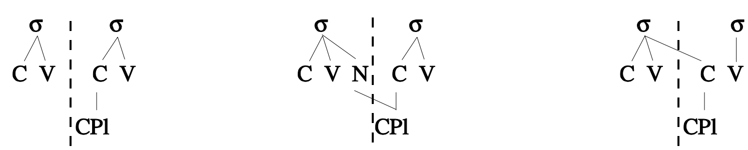
(Merchant 1994).[4,5] In order to deserve serious consideration, any proposal should ideally be informed by analyses of a large and comprehensive class of alignment cases in various languages. Even though at this point unprepared to launch into an such an investigation, we would like to venture a conjecture, on the basis of the sparse material available to us. Our proposal has two parts:

(i) The requirement that prosodic categories should have crisp edges is decoupled from the general notion "alignment", as a separate family of constraints.

(ii) Concomitantly, the formal definition of alignment is modified by replacing the upwards-tracing relation *is a* by the (less discriminating) downwards-tracing relation *is-the-content-of.*

In other words, we propose that alignment constraints are indeed fulfilled in noncrisp linkage situations. At the same time, there *is* a constraint favoring crisp edges of prosodic categories (we will call it "CrispEdge"); CrispEdge is formally independent of the various alignment constraints in terms of its function and its ranking with respect to other constraints. In order to focus ideas, consider (22): (22c) is clearly misaligned; both (22a) and (22b) fulfill alignment, but only (22a) fulfills CrispEdge.

(22) a. b. c.



Allowing noncrisp linkage, as in (22b), to fulfill alignment constraints requires only a small formal change in the definition of General Alignment. The idea is to employ, in the definition of alignment, a relation which traces downwards from a category to the terminal string and finds the category's contents. 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 (21) and the related discussion; note that the vacuous satisfaction problem independently calls for a modification of the current theory). We will make use of the relation *"is-the-content-of"*; for our purposes

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4 Merchant 1994 develops an optimality-theoretic analysis of the well-known German dorsal fricative alternations which succesfully accounts for forms with [ç] after back vowels (like *Maso[ç]ist*) by taking syllabic factors and alignment into account. Crucially, as in Lardil (see below), Gcat-to-PCat alignment must count as being fulfilled at noncrisp edges.

5 Regarding the English /r/-case, Philip Spaelti (personal communication) points out another analysis within Optimality Theory. If Align-Right (stem, PrWd), a univerally available constraint, is taken to be the crucial constraint involved, instead of Align-Left (stem, PrWd), Align-Right can (and indeed, must) count as being fulfilled at noncrisp edges in *sought Ed,* with ambisyllabic /t/. Ambisyllabic /t/ in *saw Ted,* however, is a violation of Align-Right. The difference is that /t/ is the stem-final element in *sought*, but not in *saw*. In this analysis, the constraint ranking is: {Onset, Align-Right} >> FinalC.

here, it will be sufficient to note that within a phonological representation a terminal substring A *is-the-content-of* a category Cat1 if and only if A is the maximal terminal substring dominated by Cat1 (this corresponds directly to Pierrehumbert & Beckman's (1988, 156) notion "*substantive fringe of a node*", where a more careful graphtheoretic definition can be found). Note that a string A can be *the-content-of* a category Cat1 even if some element of A is also linked to some node outside of Cat1. Equipped with this understanding of *is-the-content-of*, we can proceed to the revised definition of "alignment" in (23), which closely follows the wording in M&P 1993b except for the changes just noted.

(23) Alignment:
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-the-content-of- a* Cat1, there is [a] substring B of S that *is-the-content-of-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)).

(24) is (one 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.

(24) a. Dfn. Let A be a terminal (sub)string in a phonological representation, C a category of type PCat, and A *be-the-content-of* C. Then C is *crisp* (or: *has crisp edges*) if and only if A *is-a* PCat

b. CrispEdge[*PCat*]: *PCat* is crisp.

CrispEdge[PrWd] is of central importance and figures, for example, in the analysis of the Prosodic Morphology of Sino-Japanese compounds (see Itô & Mester 1993b); if (word-internal) ambisyllabicity in English is always foot-internal, as argued by Kiparsky 1979, 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 (24), we made no attempt to distinguish between left and right edges. If this turns out to be necessary, relativization to one edges can easily be introduced, on the model of Alignment Theory, by making use of the elementary concepts 'left edge' and 'right edge' . A more complex apparatus than the one in (24) is certainly imaginable (for example, with CrispEdge requirements coupled with particular alignment configurations), but would have to be supported by empirical evidence. Until such evidence emerges, the rather plain form in (24b) seems adequate.

Returning to the particular constraints under discussion in this section, it is now a straightforward matter to obtain the correct typology of cases. SyllSeg and SegSyll constraints (Onset, NoCoda, CodaCond) are plain alignment constraints and as such know nothing of a CrispEdge requirement. Consequently, as long as an element is linked at the edge-to-be-aligned-at, it does not matter whether the element is also linked somewhere else.

On the other hand, PrWd in English, as in many other languages, is subject to two kinds of constraints: First, there is the GCat-PCat constraint Align-Left(stem, PrWd), which again is a plain alignment constraint and as such tolerates noncrisp edges. But in addition, PrWd is subject to a CrispEdge requirement, in the sense of (24). This simple setup derives all facts about English ambisyllabicity in external sandhi, as far as we can see (provided CrispEdge(PrWd) is dominated by Onset and dominates Final-C, echoing M&P's (1993b, 48) analysis).

6 Stem Alignment in Lardil

So far we have laid out a strictly downwards-tracing definition of alignment which decouples alignment from the closely related, but independent, requirement that edges of prosodic categories should be crisp, not blurred. This slight change in the formal theory opens up a new approach to CodaCond, as shown earlier in this paper, identifying it as a SegSyll alignment constraint that forms the natural counterpart of the more familiar SyllSeg constraints. In this final section, we follow up on an independent line of argument involving a case outside of syllable theory where an alignment constraint is manifestly fulfilled in spite of noncrisp linkage. The case in question is found among the the morphology~prosody interface conditions in the Australian language Lardil.[6] The alignment constraint in question is an MCat-to-PCat constraint requiring the right edge of a stem to coincide with a syllable edge: Align-Right (stem, σ) (P&S 1991, 1993). The constraint manifests itself, among other things, in the way in which subminimal stems are augmented to fulfill the bisyllabic word minimum of Lardil (Wilkinson 1988).

Summarizing the well-known facts and P&S's (1993) analysis, we find the situation that, except for cases like (25a,b), augmentation results in the addition of a whole new syllable, with an epenthesized vowel and an epenthesized onset consonant (homorganic with the preceding coda consonant). This can be seen in (25c,d,e, and f). This at first glance curious kind of 'excess epenthesis' (multiple Fill violations) has occupied researchers for some time, in various theoretical contexts.

(25) Augmentation of short stems

a.	/yak/	☞	[yaka]	'fish'
b.	/ŗelk/	☞	[ŗelka]	'head'
c.	/maŗ/	☞	[maŗţa]	'hand'
d.	/ŗil/	☞	[ŗilta]	'neck'
e.	/kaŋ/	☞	[kaŋka]	'speech'
f.	/t^{y}aŋ/	☞	[t^{y}aŋka]	'some'

P&S's 1991 fundmental insight concerns the alignment-theoretic rationale behind this kind of phenomenon: It has nothing to do with the syllable augmentation process per se, but rather with a preference to have the end of the stem coincide with the end of a syllable. It is only

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[6] In fact, the concept of alignment within Optimality Theory was first proposed and developed for this very case (P&S 1991, at the LSA Institute in Santa Cruz).

when this is not possible (for reasons relating to CodaCond and the total exclusion of geminates in Lardil) that augmentation takes place in such a way that the end of the stem is not also the end of a syllable (25a,b).

Before proceeding, a few words are in order concerning Lardil's CodaCond, where word-internal codas are either coronal sonorants, or noncoronal sonorants homorganic with a following onset consonant. Within the theory of CodaCond developed here, this is the effect of the pair of constraints in (26a,b)[7]. The first requires all obstruents to be left-aligned with a syllable. The second requires all marked (that is, not strictly coronal) CPlace to be left-aligned with a syllable. (Marked CPlace in Lardil also includes coronals with a secondary dorsal articulation, see P&S 1993 and references cited there.) In stating (26b) in this way, we are using a method of encoding of markedness relations in optimality-theoretic grammars suggested by Kiparsky 1994. In this conception, "MarkedCPlace" is a term that can actually be referred to as such in grammatical constraints (an approach that ultimately goes back to chapter 9 of Chomsky and Halle 1968).[8]

(26) SegSyll Alignment in Lardil

a.	Align-L ([-son], σ);	obstruency alignment
b.	Align-L (Ⓜ︎CPlace, σ)	Marked-CPlace Alignment

Taking the basic word minimality effect in Lardil as a given (which derives from the requirement that every lexical word must correspond to a prosodic word, see P&S 1993 and references cited there), the syllabic fine-tuning is due the interaction between the Alignment constraint Align-Right (stem,σ) and the Fill-constraint militating against epenthesizing consonants. What we find is that the ban on epenthesizing consonants is violated so as to obey the alignment constraint: /ŗil/ → [.ŗil.TA.], *[.ŗi.lA.]. Thus the ranking of the two crucial constraints is Align-Right >> Fill[C]. Since Align-Right is violated if compelled by CodaCond (26ab), we also know that SegSyll must dominate Align-Right: /yak/ → [.ya.kA.], *[.yak.TA.]. The overall ranking must be: SegSyll >> Align-Right >> Fill[C].

At this point we are approaching what looks like a contradiction when we realize that all of the filled C's in (25) are linked C's, i.e. homorganic with the preceding (stem-final) consonant, whether they are coronal (/maŗ/ → [maŗţa], /ŗil/ →[ŗilta]) or noncoronal (/kaŋ/ → [kaŋka]). In the theory of Fill constraints developed in P&S 1993, the three outputs here look like [maŗ□□], /ŗil/ →[ŗil□□], /kaŋ/ → [kaŋ□□], the assumption being that actual featural content is supplied by the "phonetic component". More recent work by a number of researchers (see Itô, Mester, and Padgett to appear, M&P 1993a, 1993c, McCarthy 1993b, Kirchner 1993, Yip 1993, McHugh 1993, among others) has made it abundantly clear that featural insertion is controlled by the same system of constraints that is reponsible for prosodic structure. This makes it imperative to insert actual features and associations in the

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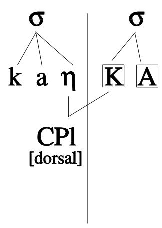
7 The two branches of CodaCond here correspond to the two path conditions in Itô and Mester 1993a (dealing with the minimal sonority threshold and consonantal place, respectively).

8 Nothing hinges on this choice in the present case, since we could equally well understand the constraint left-aligning Marked-CPlace as an abbreviation for a set of separate elementary constraints aligning individual marked CPlaces. The two approaches are subtly different in terms of their factorial-typological power, an issue outside of our present concerns.

output candidates supplied by Gen (some of these more recent developments are prefigured in note 60 in P&S (1993, 103)). In P&S's 1993 Fill theory, no alignment problem arises (in the phonology) for forms like [.kaŋ.ka.], since the epenthetic material has no phonological features and therefore cannot exhibit any multiple linking. However, if featural content is supplied within the phonological constraint system proper (as it must be, in the more recent theories), it is clear that the winning output candidate has a doubly linked structure as in (27), with a noncrisp syllable edge at the end of the stem.

(27)



If Align-right (stem, σ) were violated in a case like this (as assumed by M&P 1993a for the parallel situation in Axininca Campa, see (19) above), we would expect *[.ka.ŋa.] as the winning candidate, instead of the correct form [.kaŋ.ka.] (since both would violate Align, and the first one shows fewer Fill[C] violations).

We conclude this section, and the paper, with some tableaux showing in greater detail how our analysis of Lardil accounts for all crucial forms. For a number of undominated constraints, we have assembled the corresponding violation marks in a single column labelled "UnDom", where undominated marks are *Complex, *CodaCond, *Ons, *Ft-Bin, *Lx≈Pr. *Gem refers to a constraint against geminates (which was only informally included in P&S's 1993 analysis), and *Stric refers to a constraint preventing the alveolar r from clustering with a following homorganic consonant in (30), either for stricture reasons (Padgett 1991, 1994) or because of flap clustering conditions (McCarthy, personal communication).. For convenience, we notate segmental linking and noncrisp syllable edges by means of "$_V$", as in mar̦$_V$|Ţ A. The *PL/Artic constraints reflect the markedness ranking of all (consonantal) Place, whether present in the input or inserted, and control the way epenthetic feature structured gets filled.

(28)

	Undom	Fill-V	Align	Fill-C	*PL/ lab	*Pl/ dors	*Pl/ cor
relk.|	*Cmplx! etc.						
☞ rel.k|A							
rel.<k>	*Lx≈Pr!						
maɽ.|	*Lx≈Pr!						
maɽ.|A	*Ons!						
ma.ɽ|A		*	*!				
maɽ.|TA		*		*	*		*!*
☞ maɽ$_V$|ŢA		*		*	*		*
maɽ.|KA		*		*	*	*!	

(29)

	Un-dom	Fill-V	Align	Fill-C	*PL/ lab	*Pl/ dors	*Pl/ cor
kaŋ.|	*Lx≈Pr!						
ka.ŋ |A		*	*!				
kaŋ.|KA	*CdCnd!						
☞ kaŋ$_V$|KA		*					
kaŋ.|TA	*CdCnd!						
yak.|	*Lx≈Pr!						
☞ yak|A		*	*				
yak$_V$|KA	*Gem!						
yaŋ$_V$k|A		*	*	*!			

(30)

<table>
<tr><th></th><th>Un-
dom</th><th>Fill-V</th><th>Align</th><th>Fill-C</th><th>*PL/
lab</th><th>*Pl/
dors</th><th>*Pl/
cor</th></tr>
<tr><td>bit.|</td><td>*Lx≈Pr!</td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td></tr>
<tr><td>☞ bi.t|A</td><td></td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td></tr>
<tr><td>bit.|TA</td><td>*CdCnd!</td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td></tr>
<tr><td>bit$_V$|TA</td><td>*Gem!</td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td></tr>
<tr><td>ter.|</td><td>*Lx≈Pr!</td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td></tr>
<tr><td>☞ te.r|A</td><td></td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td></tr>
<tr><td>ter.|TA</td><td>*OCP!</td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td></tr>
<tr><td>ter$_V$|TA</td><td>*Stric!</td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td></tr>
<tr><td>ter$_V$|RA</td><td>*Gem!</td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td></tr>
</table>

In Lardil's constraint system, epenthetic feature structure is filled by double linking, if possible: Since every articulator feature incurs a mark *Pl/Artic (P&S 1993, McCarthy 1993b, Smolensky 1993, M&P 1993c), it pays to minimize place specifications by invoking the "spreading" option, instead of inserting new features (even unmarked ones). Only if the resulting mutiple linking option is impossible does unmarked coronality have a chance to emerge (but does not, in this case, due to higher-ranking constraints like CodaCond). Homorganicity, then, is a constraint interaction effect in Lardil, and not a constraint by itself.

7 Conclusion

Returing to our overall theme, we see that it would be pernicious in a case like Lardil to insist on crisp edges when assessing alignment violations. Alignment itself is defined in such a way that crispness of edges is irrelevant (see the definition in (23)). This allows us to develop a new alignment-theoretic typology of syllabification principles, with closely corresponding SyllSeg and SegSyll constraints. Divorced from alignment per se, crispness of edges is an independent constraint on prosodic units (24). Naturally, we expect there to be situations where both alignment and crispness are involved, and indeed find them in English ambisyllabicity in external sandhi and in Axininca Campa stem-syllable alignment.

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