Phonology at Santa Cruz, Vol. 3, 1994, pp. 79-85

Directional Syllabification in Generalized Alignment[1]

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One of the central analytical strategies of generative phonology in the past has been the attempt to explain all **directionality effects** as the result of **directional structure building algorithms** which move in a step-by-step iterative fashion from one end of an input form to the other end. As an example, consider the familiar case where disyllabic trochaic feet are built from left to right (as in Pintupi, according to Hayes 1991). Given an input with an odd number of syllables like **/SSSSSSS/** (S=syllable), the relevant part of its derivational history looks as follows: **/SSSSSSS/** **[SS]SSSSS** **[SS][SS]SSS** **[SS][SS][SS]S**, terminating in a representation where the foot parse is flush with the left edge, but not with the right edge (i.e., with a left-edge directional bias). For the same kind of input, right-to-left foot building yields the opposite result: **S[SS][SS][SS]**.

In other words, standard derivational models of phonology seek the explanation for such kinds of directional bias in the way in which the output structures have been built up during the derivation, piece by piece. Directionality effects are not limited to prosodic phonology and have been found and diagnosed in essentially all areas of phonology and prosodic morphology, including tonal association, segmental processes, harmony processes, feature-sized morpheme associations, etc.

As is well known, Optimality Theory (Prince and Smolensky 1993), an approach based exclusively on wellformedness constraints instead of operations, proposes to do away with a sequential derivation.[1] In its place, the theory posits parallel evaluation of an indefinitely large and inclusive pool of candidate outputs. This evaluation results in the selection of the candidate(s) that optimally satisfy a given set of strictly ranked constraints. These constraints, the totality of which make up the grammar (here, phonology) of a language, are in principle all violable; optimality consists in minimal violation (see Prince and Smolensky 1993, McCarthy and Prince 1993a,b,c, Itô, Mester, and Padgett (1993, to appear) and other related work for further discussion).

In its crucial reliance on the existence of a sequential derivation, the derivational theory of directionality effects is sometimes perceived as a serious obstacle to modern constraint-based theories; the issue arises in a number of constraint-based frameworks other than Optimality Theory, all of which shun sequential derivations e.g., Declarative

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This note was first posted, in essentially its present form, as an electronic text in the Rutgers Optimality Archive (Fall 1993). We gratefully acknowledge significant help from discussions and correspondence with Junko Itô, Ellen Broselow, John McCarthy, Alan Prince, Cheryl Zoll, and PASC editors Jason Merchant and Rachel Walker. It was Zoll's work on Yawelmani Yokuts (Zoll 1993) that first inspired us to confront the issues dealt with in this note. As usual, all remaining shortcomings are our responsibility alone.

[1] Though not with level ordering. See McCarthy and Prince 1993a for some argumentation.

Phonology (Scobbie 1991, 1993, Broe 1993), Harmonic Phonology (Goldsmith 1990, 1991), and others.

In their paper introducing Generalized Alignment, McCarthy and Prince (1993b) (henceforth, GA) have developed a technique for capturing directional foot parsing effects in Optimality Theory. Building on this work, the purpose of the present note is a very modest one: we would like extend their result to directional syllabification effects, which were systematically explored and analyzed, in the context of an overall prosodic theory of syllable structure, in Itô's work (Itô 1989, 241-254; 1986, 163-219).

Somewhat comparable to the reanalyses of 'phonotactics plus repair' theories found in chapter 10 of Prince and Smolensky 1993, the status of our work is very much that of a demonstration of existence: we show, for a representative case with directional syllabification effects, how an optimality-theoretic equivalent to the standard operational analysis can be constructed. We are not claiming that the analysis outlined is necessarily the best way of capturing the effects. In particular, our reconstruction is strictly based on Itô's (1986, 1989) work and does not take into account the results of work done since then.

Our proposal makes use of a central analytical strategy in GA, where directionality effects in foot parsing are derived by means of a constraint requiring the alignment of every foot edge (left/right) with a prosodic word-edge (left/right). As demonstrated in GA, the doctrine of minimal violation ensures the selection of the candidate displaying the desired directional footing pattern (a suggestion originally due to R. Kirchner). This is so in spite of massive violations of the alignment constraint incurred by all feet not directly located at the relevant word edge.

Taking up the alignment strategy of GA, we show that directional syllabification patterns are the result of alignment constraints requiring that every syllable edge coincide with a prosodic word-edge. The general schema is given in (1), where E(dge) is a variable ranging over {L(eft), R(ight)} and 'Syll' abbreviates 'syllable':[2]

(1) Syll-Align (Syll,Edge,PrWd,Edge)

For clarification, we note that this statement is to be interpreted as quantifying **universally** over tokens of Syll and **existentially** over tokens of PrWd (see GA for a more formal development and for further exemplification): **every** syllable must be Edge-aligned with **some** prosodic word. In most situations, (1) is massively violated by syllables not located at Edge. For a given input, the optimal candidate is the one with the fewest violations (modulo the overall ranking of constraints, as usual in OT).

Right-Left (R-L) syllabification and epenthesis (as in Iraqi Arabic; see Itô 1989, who builds on analyses of Broselow 1980, 1982 and Selkirk 1981) shows the pattern in (2) (the 'Coda'- pattern: the stray *c* is syllabified as a coda to the epenthetic vowel, whose site is marked by capital 'V'):

(2) [...]cvcccv[...] [...].cv.cVc.cv.[...]

[2] John McCarthy and Alan Prince independently pointed out the feasibility of such a 'same-edge' analysis. Our original proposal was stated in opposite-edge terms. See below for discussion.

Thus /gil-t-l-a/ appears as *.gi.lIt.la.* 'I said to him', etc. This pattern follows from the L-Edge version of the alignment constraint in (3), under the overall constraint ranking in (4) (see Prince and Smolensky 1993 and McCarthy and Prince 1993b on constraint formulations).

(3) Syll-ALIGN(L): Align (Syll,L,PrWd,L)

(4)

ONSET	>>	Syll-ALIGN(L)	>>	NO-CODA
PARSE		FILL		
*COMPLEX				

In order to see how this works, the reader is invited to inspect the tableau in (5), which demonstrates that a gradiently violable understanding of Syll-Align achieves the needed directionality effect.[3] We leave out the undominated constraints for the purposes of the present discussion. Taking up a suggestion by John McCarthy, we assume that violations of alignment constraints are reckoned in terms of the prosodic unit immediately adjacent (one level down) in the prosodic hierarchy from the unit referred to in the first part of the constraint. (3) quantifies universally over syllables (loosely, "is a constraint on syllables"), hence it makes sense for violations to be computed in terms of mora count.[4] Let us focus on the violations of Syll-Align(L) here, given syllable-by-syllable for convenience. The constraint, recall, requires every Syll to be left-aligned with PrWd. The first syllable of any form satisfies the constraint completely, naturally, and so no violations are counted in the first column. Some differentiation occurs, however, already by the second syllable, which in candidate (5b) fails Syll-Align(L) by two moras. We do not indicate a fatal violation in this column; as McCarthy and Prince (1993b) note, the desired result can be had by taking together at once violations incurred by **all** syllables. Thus, the optimal candidate (5a) violates Syll-Align(L) by four moras total; (5b,c) are removed from consideration by incurring five violations or more.

(5) Align(L) syllabification tableau (corresponds to R-L syllabification)

	FILL	Syll-ALIGN(L)				NoCoda	
/cvcccv/		S1	S2	S3	S4		
a. cv.cVc.cv	*		m	mmm		*	$
b. cvc.cV.cv	*		mm	mmm!		*	
c. cv.cV.cV.cv	**(!)		m	mm	mm(!)m		

[3] The format of our constraint tableau, lifted directly from a previous ASCII instantiation, should be understood as follows: 'm' denotes a mora; (!)...(!) indicates indeteminacy of fatality of violation, given the indeterminacy of ranking between Fill and Syll-Align. The optimal form is marked on the right of the tableau with '$', in the notation of Grimshaw (1993).

[4] As comparison of (5a &b) should make clear, we cannot achieve the directionality effect by counting syllables themselves. On the possibility of counting segments, see later discussion.

L-R syllabification and epenthesis (as in Cairene Arabic; see Itô 1989 and references therein) shows the pattern in (6) ('Onset'-pattern: the stray *c* is taken as the onset to the epenthetic vowel):

(6) [...]cvcccv[...] [...].cvc.cV.cv.[...]

Thus /?ul-t-l-u/ appears as *.?ul.tI.lu.* 'I said to him', etc. This pattern follows from the R-Edge version of the alignment constraint (7), under the overall constraint ranking in (8) (which is identical to that of (4) in all other respects).

(7) Syll-ALIGN(R): Align (Syll,R,PrWd,R)

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(8)   | ONSET      |     >>     |Syll-ALIGN(R)     |     >>     NO-CODA
      | PARSE      |            | FILL             |
      |*COMPLEX    |
```

Tableau (9) illustrates this point. Though 'S1' still denotes the initial syllable, Syll-Align(R) now requires that it be aligned with PrWd at the right edge. Candidate (9b) is the winner.

(9) Align(R) syllabification tableau (corresponds to L-R syllabification)

```
               || FILL  :   Syll-ALIGN(R)                   |  NoCoda
===============||=======:================================|==========
   /cvcccv/    ||       :   S1   S2     S3      S4          |
---------------||-------:--------------------------------|----------
a. cv.cVc.cv   ||  *    :   mmm  m!                         |    *
---------------||-------:--------------------------------|----------
b. cvc.cV.cv   ||  *    :   mm   m                          |    *     $
---------------||-------:--------------------------------|----------
c. cv.cV.cV.cv ||  **(!):   mmm  m(!)m  m                   |
---------------||-------:--------------------------------|----------
```

The major result of Itô's (1989) analysis is its ability– without invoking any additional constraints– to account for the convergence of the two opposing patterns (R-L: Iraqi Arabic; L-R: Cairene Arabic) in the case of *cccc* clusters: both languages syllabify this case as in (10).

(10) [...]cvccccv[...] [...].cvc.cVc.cv.[...]

Thus R-L Iraqi Arabic syllabifies /gil-t-l-ha/ as *.gil.tIl.ha.* 'I said to her', and L-R Cairene Arabic answers by syllabifying /?ul-t-l-ha/ as *.?ul.tIl.ha.* 'I said to her', etc. Our alignment analysis replicates Itô's result, as demonstrated without commentary in (11) and (12).

(11) Align(L) syllabification of /...cccc.../

```
            || FILL   :   Syll-ALIGN(L)                    |  NoCoda
============||=======:=================================|==========
/cvccccv/   ||       :   S1   S2      S3      S4        |
------------||-------:---------------------------------|----------
cvc.cVc.cv  ||  *    :         mm     mmmm              |    **    $
------------||-------:---------------------------------|----------
cvc.cV.cV.cv||  **(!):         mm     mmm     mm(!)mm   |    *
------------||-------:---------------------------------|----------
cv.cV.cVc.cv||  **(!):         m      mm      mmmm(!)   |    *
------------||-------:---------------------------------|----------
```

(12) Align(R) syllabification of /...cccc.../

```
            || FILL   :   Syll-ALIGN(R)                    |  NoCoda
============||=======:=================================|==========
/cvccccv/   ||       :   S1   S2      S3      S4        |
------------||-------:---------------------------------|----------
cvc.cVc.cv  ||  *    :   mmm  m                         |    **    $
------------||-------:---------------------------------|----------
cvc.cV.cV.cv||  **(!):   mmm  mm(!)   m                 |    *
------------||-------:---------------------------------|----------
cv.cV.cVc.cv||  **(!):   mmmm m(!)mm  m                 |    *
------------||-------:---------------------------------|----------
```

This approach derives the Maximality effect (Itô 1989, reanalyzing Selkirk's 1981 principle of syllable number minimization) as a theorem: the more syllables, the more Fill violations, and the more alignment violations. Hence Itô's directionality-driven convergence effect between L-R and R-L systems in *cccc* clusters follows directly, without additional legislation. The redundant overlap between Fill and Align should be noted; on the positive side, it should also be noted that Maximality effects can be obtained, in this approach, **independent** of the domination status of Fill (i.e., independent of epenthesis), opening up new possibilities of analysis which are perhaps needed elsewhere.

Perhaps a more disturbing finding is the fact that, in the current version of Generalized Alignment Theory, the L-R and R-L patterns can also be derived under an **Opposite Edge** setting of the alignment constraints, i.e. as Align(Syll,Edge,PrWd,Edge'), as the reader may verify for her/him-self by recasting the tableaux given above in the appropriate way. And they can be derived by counting segments instead of counting moras. They can even be derived with a strictly segmental setting, requiring each **segment** to be as closely aligned to one edge as possible– this is sufficient to push the epenthetic vowel as far in the opposite direction as possible, with multiple epenthesis discouraged as before. Aside from the question whether such possibilities are required or desirable (e.g. could segmental count be necessary to derive directionality in a language without weight distinctions, where there is no coda mora to count?), we can conclude that the theory of GA needs to be tightened up. The task is to isolate, among the set of statements of the form 'Align(x,Edge(i),y,Edge(j))' made available by the general Alignment scheme, those that have true linguistic significance.

In conclusion, we return to the beginning: what we have tried to demonstrate here is the existence of a method for capturing directional syllabification effects in Optimality Theory. It seems quite clear that our proposal is only an initial step, and we are convinced that it can be improved on in many ways. Our demonstration and argumentation has remained abstract and schematic throughout, using the contrasting Arabic cases merely as convenient demonstration objects for our method: our goal was to replicate directionality effects as they were argued to exist in earlier literature (Itô 1986, 1989). Some recent research has indicated that, taken seriously as purported instances of directional syllabification patterns, Arabic dialects present a host of further issues that would have to be dealt with. Both John McCarthy and Ellen Broselow have pointed out that all the proposals presented above fail to adequately deal with the way in which **initial** *#cc* clusters are resolved in the various dialects of Arabic (see Broselow 1992). Since we are not familiar with the empirical details, we refrain from fabricating hypotheses, and leave the issue unresolved. In fact, it is not unthinkable that the ultimate analysis of Cairene and Iraqi Arabic cases does not even involve directionality, but rather other factors (as argued in Broselow 1992).

We note that **some** cases of special behavior in PrWd-initial position, in non-Arabic languages, have a straightforward account in our scenario. Thus Itô (1989, 252-254) analyzes Temiar epenthesis as basically R-L (Coda-preference; in our terms, ALIGN-L), in spite of the fact that **initial** *#ccv* configurations are resolved as *#.cV.cv...* and not as *#.Vc.c*v... This follows directly in our approach: in *#.cV.cv...*, the second syllable is separated from the initial word edge by one mora; in *#.Vc.cv...*, the mora count is two. Again we find some explanatory redundancy, however: Onset is a dominating constraint in Temiar, as pointed out by Itô (1989), whose gradiently fulfillable principle 'Avoid Onsetless Syllables' is among the precursors of current Optimality-Theoretic reasoning.

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