Monotonic Cyclicity

Cemil Orhan Orgun
U. C. Berkeley

1. Introduction

Evidence for cyclicity (e.g. Mascaró 1976; Kiparsky 1982, 1993; Hargus 1993; Inkelas 1993, Hyman 1994) seems to pose a serious challenge to nonderivational approaches to phonology (e.g., Koskenniemi 1983, Bird 1990, Scobbie 1991, Goldsmith 1993, Karttunen 1993, Lakoff 1993, Prince and Smolensky 1993). Cyclic phonology is thought to require serial derivations, but serial derivations are cognitively implausible (see, for example, papers in Goldsmith 1993b). Proponents of nonderivational phonology have responded to this issue in two very different ways:

i) Recent work in Optimality Theory (Prince and Smolensky 1993) claims that cyclic effects are an epiphenomenon resulting from constraints on alignment between morpheme edges and metrical constituents (McCarthy and Prince 1993). This approach is based on the tacit assumption that all cyclic effects occur near morpheme junctures.

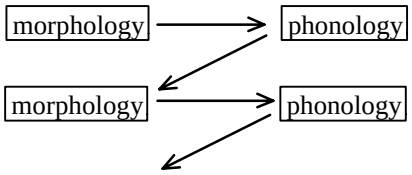
ii) Harmonic Phonology and related approaches (Goldsmith 1993, Lakoff 1993; cf. Cole 1990) assume a small, fixed number (usually three) of parallel phonological representations or "levels" with constraints on correspondences between levels. This approach is based on the assumption that exactly two applications of phonology are required regardless of the morphological structure of a form.

This paper presents two cases of cyclic phonology which do not yield to either approach. I then propose a new model of the phonology-morphology interaction which preserves the advantages of nonderivationalism (and is consistent with Optimality Theory), yet derives cyclic effects as an automatic consequence.

1.1 Cyclicity in Lexical Phonology

Although there are early cyclic analyses in phonology (e.g., Chomsky, Halle and Lukoff 1956, Halle 1963, Schane 1965, Lightner 1965, McCawley 1965), the term cyclicity has come in modern phonological literature to be equated with the theory of Lexical Phonology (Kiparsky 1982, Mohanan 1982, 1986). The aversion to cyclicity among nonderivational phonologists is perhaps partly caused by the unfortunate factory metaphor used in Mohanan's (1986) implementation of Lexical Phonology.[1]

(1)



The following quote from Goldsmith illustrates a typical reaction to Lexical Phonology:

---

[1] Perhaps another reason that the idea of cyclicity in phonology has attracted so much hostility is because it is assumed to be the counterpart in phonology of cyclic rule application in syntax, which has been abandoned with the switch from Transformational Grammar to non-rule-based approaches to syntax. However, as we will see, cyclicity in modern theories of phonology in fact does not correspond to the transformational cycle in syntax at all; if an analogy is to be found in syntactic theory, feature percolation is probably the best available.

> Much of the material discussed here arose out of a critical analysis of Lexical Phonology, which depends heavily on what appear to be thorough-going uses of an implausible metaphor involving space and time: "First add an affix, then send that material through a set of rules which modifies the resultant form; then go to the next level, add another affix, and finally string all the words together, only after which do we reach a point where the postlexical rules get a chance to apply." The hope is implicit in such an account that the ungainly metaphors are present only for expository reasons; but as I attempted to extract the essence from the packaging, for my own purely pedagogical purposes, I slowly, and reluctantly, came to the conclusion that the operation left little behind. (1993: 21)

My own reaction to Lexical Phonology is somewhat different; as summarized below:

> As I attempted to extract the essence from the packaging, for *my* own purely pedagogical reasons, I slowly, yet eagerly, came to the conclusion that a great insight remained.

The goal of this paper is to develop a unification-based formalism from which the major insight of Lexical Phonology, the interleaving of phonology and morphology, follows, and to briefly explore the desirable theoretical and cognitive aspects of such an approach. The case studies I present illustrate rule interaction paradoxes and inside-out effects, which are among the major motivations of cyclic phonology.

2. The insufficiency of past approaches

In this section, I present two case studies which show that neither the alignment approach of Optimality Theory nor the parallel representations approach of Harmonic Phonology can handle all cases of cyclic phonology.

2.1 The alignment approach

McCarthy and Prince 1993 have shown that some cyclic effects can be accounted for by constraints on alignment between morpheme edges and metrical constituents. I illustrate this approach by presenting a noncyclic reanalysis of Poser's (1989) cyclic account of Diyari stress. I do not claim that this reanalysis is superior to Poser's original cyclic analysis. The sole purpose of this section is to illustrate the Generalized Alignment formalism by showing how it provides noncyclic alternatives to some traditional cyclic analyses. In later sections, we will see cases of cyclic phonology that cannot be analyzed noncyclically in the Generalized Alignment formalism.

Diyari stress (Poser 1989)

In monomorphemic words, primary stress falls on the first syllable, and secondary stress on all odd-numbered syllables, except for the ultima.

(2)	kána	'man'	pínadu	'old man'
	nánda	'to hit'	púluru	'mud'
	ŋándawàlka	'to close'	mánkara	'girl'

Morphologically complex words are stressed in a similar way, except for the requirement that the first syllable of every polysyllabic suffix is stressed, even if it happens to be an even-numbered syllable. Morpheme-final syllables are never stressed. As a result, monosyllabic suffixes do non receive any stress.

(3)	kána-wàra-ŋùndu	'man-pl-abl'	máda-la-ntu	'hill-charac-propr'
	ŋándawàlka-tàdi	'to close-pass'	púluru-ni-màta	'mud-loc-ident'
	táyi-yàtimàti	'to eat-opt'	pínadu-wàra	'old man-pl'
	kána-wàra-ŋu	'man-pl-loc'	yákalka-yìrpa-màli-na	'ask-ben-recip-part'

Poser presents a simple cyclic account of Diyari stress. He assumes that binary left-dominant quantity-insensitive feet are assigned cyclically from left to right. If there is a leftover syllable, it is assigned a degenerate (monosyllabic) foot. Poser evokes the Free Element Condition (Prince 1985) to account for the fact that feet do not cross morpheme boundaries. Since the final syllable of a stem will already be dominated by a foot (either binary or degenerate) at the time when a new suffix is added, footing on the next cycle will start from the initial syllable of the new suffix. Finally, a postcyclic defooting rule removes all degenerate feet, and the first stress is made prominent.

(4)	Root cycle	(x .) (x) pu lu ru	
	1st affix cycle	(x .) (x) (x) pu lu ru ni	
	2nd affix cycle	(x .) (x) (x) (x .) pu lu ru ni ma ta	
	Postcyclic defooting	(x .) (x .) pu lu ru ni ma ta	
	Surface	púlurunimàta	

I now present a noncyclic analysis of Diyari stress using Generalized Alignment. We need the following constraints, which I present rather informally here for ease of exposition:[2]

(5)
i) FtForm: Trochee
ii) No morpheme-final stress (NoAlignR (Morpheme, R, σ, R))
iii) Parse σ (by Foot)
iv) Feet want to be at the left edge: AlignL (F, L, Stem, L)

These constraints are ranked as shown in (6). The first two constraints are never violated in the data we are considering here.

(6) {FtForm, NoAlignR} ≫ Parse σ ≫ AlignL

The tableau in (7) illustrates how these constraints account for Diyari stress. Notice that it is better to leave a syllable unfooted (a parse violation) than to assign a degenerate foot or a foot that crosses morpheme boundaries.[3] The numbers in the rightmost column measure the distance

---

[2] The constraints are assumed to be universal, and their ranking language particular. A constraint may be violated only if a higher-ranked constraint can be satisfied by doing so. See Prince and Smolensky 1993 and McCarthy and Prince 1993 for details.

[3] This analysis suffers from a criticism Poser used against alternative analyses he considered in his Diyari paper: He observes that phonological rules normally do not make direct reference to the internal morphological structure of words. In particular, in a stem-affix combination, the stem itself may be an exclusive rule domain (by virtue of having undergone a cycle prior to the addition of the affix), but affixes are never exclusive rule domains. In a cyclic analysis that assumes bracket erasure,

of the left edge of each foot from the left edge of the word. As discussed in Prince and Smolensky 1993 and McCarthy and Prince 1993, the exact measure used is irrelevant. All that is required is a way of comparing distances across candidates. I use syllable count as a measure here simply because of its visual simplicity.

(7)

/puluru-ni-mata/	FtForm	NoAlignR	Parse σ	AlignL
(x .) (x) (x) (x .) pu lu ru ni ma ta	**!	**		2+3+4
(x .) (x .) (x .) pu lu ru ni ma ta		*!		2+4
(x .) (x .) pu lu ru ni ma ta		*!	**	3
☞ (x .) (x .) pu lu ru ni ma ta			**	4
(x .) (x .) pu lu ru ni ma ta			**	1!+4

In this section, we have seen that the Generalized Alignment framework of McCarthy and Prince makes it possible to formulate noncyclic alternatives to some cyclic analyses. In the following section, I will argue that this is not always possible. That is, I will show that the need for cyclicity still remains.

2.2 Turkish voicing alternations

In this section, I present a case of cyclic phonology that does not admit a noncyclic reanalysis in the Generalized Alignment framework. In Turkish, root-final plosives underlyingly unspecified for voicing surface as voiced in onset and voiceless in coda position (Kaisse 1986, Rice 1990, Inkelas and Orgun 1993).

(8)

	Alveolar			Labial and palatal		
	Nominative	Accusative	Gloss	Nom.	Acc.	Gloss
Alternating	kanat	kanad-ɨ	‘wing’	kitap	kitab-ɨ	‘book’
	kilit	kilid-i	‘lock’	a.ač	a.ǎj-ɨ	‘tree’
Non-alternating	sanat	sanat-ɨ	‘art’	*None*		
	anɨt	anɨt-ɨ	‘monument’			
	pɨrelüd	pɨrelüd-ü	‘prelude’			
	etüd	etüd-ü	‘study’			

Notice that final labial and palatal plosives of polysyllabic roots always undergo these alternations. A simple analysis would be to say that plosives unspecified as to voicing are assigned voicing in onsets and voicelessness in codas. This assignment is purely structure-filling (i.e., it is more important to keep underlying voicing specifications than to obey voicing constraints), accounting for the nonalternating final alveolar plosives.[4]

The regular behavior for final plosives of monosyllabic roots, however, is to be consistently voiceless, whether in surface onset or coda position. Crucially, this is true for labial and palatal as well as alveolar plosives.

---

this follows as a natural consequence. In noncyclic analyses, including the present one, it is impossible to capture this generalization.

4 The fact that there are no labial and coronal root-final plosives underlyingly specified for voicing can perhaps be accounted for by a constraint on the complexity of underlying representations, such that no root-final plosive may have both a place node and a laryngeal node underlyingly.

(9)

Alveolar			Labial and palatal		
Nominative	Accusative	Gloss	Nom.	Acc.	Gloss
at	at-ɨ	‘horse’	hap	hap-ɨ	‘pill’
ot	ot-u	‘grass’	top	top-u	‘ball’
it	it-i	‘dog’	pič	piči	‘bastard’
et	et-i	‘meat’	kɨč	kɨčɨ	‘ass’

The productivity of these patterns is confirmed by recent loans.

(10)

Nominative	Accusative	Gloss
teleskop	teleskob-u	‘telescope’
mikroskop	mikroskob-u	‘microscope’
tüp	tüp-ü	‘tube’
küp	küp-ü	‘cube’

The fact that a monosyllabic root-final plosive exhibits the coda effect of devoicing even if it surfaces as an onset can be analyzed straightforwardly in a cyclic model. Following Rice 1990, I assume that devoicing applies cyclically, but root final plosives are protected from devoicing on the root cycle by extrametricality (which can be implemented as an alignment constraint that prevents the root final consonant from being syllabified; see McCarthy and Prince 1993). When affixation renders the consonant non-final, it is directly syllabified into its surface position, acquiring the appropriate laryngeal specification.[5] In monosyllabic roots, the final consonant is forced to syllabify on the root cycle by an independently needed, higher ranked bimoraic minimal size condition (Orgun and Inkelas 1992), and devoices on the root cycle. Example (11) illustrates these alternations (angled brackets indicate unsyllabified segments).

(11)

	underlyingly voiceless	underlyingly unspecified	underlyingly unspecified
	‘art’	‘book’	‘pill’
UR	sanat	kitaB	haB
Root cycle	sana<t>	kita<B>	hap
Affix cycle	sanat-ɨ	kitab-ɨ	hap-ɨ
Surface	sanatɨ	kitabɨ	hapɨ

A noncyclic account would have to claim that the plosive in question is actually a coda in the output. This would require a further level of phonological representation in which the consonant in question is an onset (since we know that it is an onset in the surface phonetic form). However, this approach is not tenable, for various reasons. First, phonological codas in Turkish are realized as phonetic onsets only optionally. It is always possible to insert a glottal stop rather than resyllabify (e.g., across word boundaries). But in the suffixed forms in (11), resyllabification is obligatory. Since phonetic implementation should not be sensitive to morphological information, we have to conclude that the root final consonants are *phonologically* onsets (it is natural to expect that resyllabification is obligatory in the lexical phonology, but optional postlexically). Thus, we have to admit multiple phonological representations to solve the problem of Turkish voicing alternations. In the next section, I show that the number of such parallel representations has to depend on the morphological structure of

[5] The phenomenon is actually somewhat more complicated than presented here. Root final plosives may optionally be syllabified across word boundaries if followed by a vowel initial word, and surface as voiced. See Kaisse 1986, Rice 1990, Inkelas and Orgun 1993 for details and analysis.

a form (cyclic phonology), rather than being predetermined (e.g., as lexical, postlexical, and phonetic).

2.3 The Harmonic Phonology approach

Goldsmith 1993 and Lakoff 1993 use three parallel phonological representations to account for some rule interaction and cyclic effects. The main assumptions in this approach can also be found in Cole 1990, who proposed a two-cycle serial derivation. Cole's approach is based on two apparent observations (although she only mentions the first one explicitly in her paper, the second observation is necessary for her account as well):

i) One never needs more than two cycles of phonological rule application.
ii) It never hurts to have more than one cycle of phonological rule application.

If these observations are correct, one does not need a phonological cycle for each affix. Instead, one can assume a model in which every form undergoes exactly two cycles, regardless of its morphological structure. Goldsmith 1993 and Lakoff 1993 propose a declarative approach based on the same intuition. In their approach, there are three parallel phonological representations related to each other by constraints (or "constructions").[6]

(12)
M-level phonological representation
↕ M-W constructions
W-level phonological representation
↕ W-P constructions
P-level phonological representation

I illustrate how this approach can handle a counterbleeding interaction between phonological rules. In Uighur, vowels raise in morpheme final open syllables (except word-finally):[7]

(13)

kala	'cow'	kalɨ-ɣa	'cow-dative'
tuxa	'chicken'	tuxɨ-dan	'chicken-ablative'
qazan	'pot'	qazɨn -i	'pot-possessive'
bala	'child'	balɨ-si	'child-possessive'
ana	'mother'	anɨ-lar	'mother-plural'
ameriqa	'America'	ameriqɨ-da	'America-locative'

This alternation can be expressed as a cross-level correspondence as shown below.[8]

---

6 Note that Lakoff's model is equivalent to the two-level model of Karttunen 1993: His cross-level mapping is Finite State, and any multi-level Finite State model is equivalent to a two level one, as shown by Johnson 1972 and independently by Kay and Kaplan 1982. But Goldsmith's model cannot be reduced to two levels because of his "intralevel" rules. I will, therefore, continue to focus on the three level representation in this paper.

7 The Uighur data come from my field work with Enver Yusuf, a native speaker of the Qashgar dialect. I have not been able to found any descriptions of this dialect in the literature.

8 Note that one needs to interpret the morpheme boundary symbol rather loosely— how to define the morpheme membership of a syllable given that syllables often include segments from more than one morpheme, is a question that is difficult, perhaps impossible, to answer. This observation constitutes a rather strong objection to theories that make direct reference to morpheme boundaries as objects (e.g., SPE (Chomsky and Halle 1968), Karttunen 1993, Lakoff 1993, Goldsmith 1993). This point is pursued in Orgun 1994.

(14)

Level X:	$V]_\sigma$ + σ		example:	
	↕		X:	qaz a n + i
Level Y:	V			↕
	|		Y:	qaz ɨ n + i
	[+hi]			

Another rule of Uighur phonology is that high vowels elide in the two-sided open syllable environment between identical consonants.

(15) qazɨn̲i̲ + ni → qazɨnni 'pot-possessive-accusative'

This rule can also be stated as a cross-level constraint (ε denotes the empty string).

(16)

Level X:	V	C_i	V	C_i	V		
			|				
			hi				
			↕				
Level Y:			ε				

The example in (17) shows that the two rules are in a counterbleeding relation. The elided high vowel still causes the preceding vowel (indicated by double underlining) to raise.

(17)

	qazan + i + ni	→	qaz̲i̲nni	'pot-possessive-acc'
cf.	qazan + ni	→	qazanni	'pot-acc'

One way to capture this rule interaction is by assigning the two constructions two different levels (it is also possible to use two constructions relating the same two levels, but we need not be concerned with this alternative here, since the arguments I present below against this approach apply regardless of the number of levels involved). The form *qazɨnni* is then licensed as shown below.

(18)

M:	qaz a n	+	i	+	ni	
	↕					
W:	qaz ɨ n	+	i	+	ni	
			↕			
P:	qaz ɨ n	+	ε	+	ni	

I will now show that this analysis fails to account for the whole range of interactions between these two rules. Given the right morphological structure, raising can *feed* elision.

(19)

i)	qazan + i	→	qazɨni		
ii)	qazan + ni	→	qazanni		
iii)	qazan + i + ni	→	qazɨnni	(*qazanni)	*elision counterbleeds raising*
iv)	bala + lar	→	balɨlar	(*ballar)	*raising counterfeeds elision*
v)	bala + lar + i	→	ballɨri	(*balɨlɨri)	*raising feeds elision*
vi)	bala + lar + ni	→	ballarni		*raising feeds elision*
vii)	bala + lar + i + ni	→	ballɨrɨni		*raising feeds elision*
viii)	ana + ni	→	anɨni	(*anni)	*raising counterfeeds elision*

This is the classic type of rule interaction paradox that motivates cyclic phonology. The three-level approach of Goldsmith 1993 and Lakoff 1993 fails to account for these data. The reason is that the number of cycles (or levels) in those approaches is fixed. But the Uighur data crucially require the number of phonological cycles to depend on the morphological structure of the form.

(20)

	if raising feeds elision			if raising counterfeeds elision	
M:	bala + lar + ni	bala + lar	M:	bala + lar + ni	bala + lar
W:	balɨ + lar + ni	balɨ + lar	W:	balɨ + lar + ni	balɨ + lar
P:	bal + lar + ni	*bal + lar	P:	*balɨ + lar + ni	balɨ + lar

A cyclic analysis is easily formulated. I assume that raising counterfeeds elision on the cycle.[9] If the form undergoes another cycle of phonology due to the presence of an additional suffix, then elision applies.

Example (21) shows how the cyclic analysis accounts for the apparent rule ordering paradox. The rightmost form in (21) undergoes a single phonological cycle, which explains why the high vowel surfaces, whereas the other two forms undergo two cycles, with the high vowel eliding in the second cycle.

(21)

		‘pot-poss-acc’	‘child-pl-acc’	‘child-pl’
Cycle 1	input	qazan-i	bala-lar	bala-lar
	output	qazɨn-i	balɨ-lar	balɨ-lar
Cycle 2	input	qazɨni-ni	balɨlar-ni	—
	output	qazɨn-ni	ballar-ni	—
Surface		qazɨnni	ballarni	balɨlar

In order to account for the difference between *balɨlar* (*bala+lar*, ‘child-plural’) and *ballarni* (*bala+lar+ni*, ‘child-plural-accusative’), the number of phonological cycles must crucially depend on the number of suffixes. In *balɨlar*, only one affix is added. In the phonological cycle triggered by that affix, elision is bled by raising. In *ballɨri*, a further affix is added, and the form undergoes an additional cycle. Elision applies in this second cycle. The fatal flaw in the Harmonic Phonology approach is that every form undergoes the same number of applications of phonology, regardless of the morphological structure. Notice also that alignment does not give us a way to analyze these data noncyclically, since the accusative suffix *-ni* adds nothing to the environment for elision; all it does is cause an additional phonological cycle.

3. A new approach: Monotonic Cyclicity

We have seen that it is crucial for the number of phonological cycles to depend on morphological structure. Past nonderivational approaches fail to account for all cyclic effects because they assume a fixed number of levels of application for phonology. In this section, I propose a new, nonderivational, approach to the phonology-morphology interaction that does not face the same difficulty.

3.1 Overview

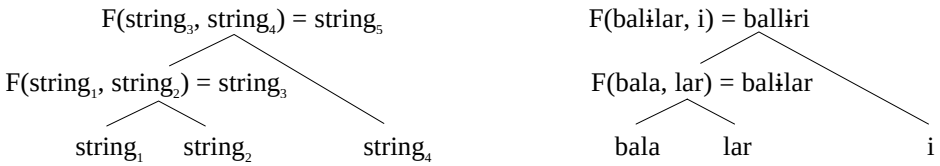
Following Sproat 1985, Inkelas 1989, and others, I assume a phonological constituent structure tree for morphologically complex words. In addition, I propose that each node of the tree is a phonological string, complete with segmental and metrical structure. Each node in such a tree is a function of the nodes it immediately dominates (except for terminal nodes, which are the underlying strings supplied by morphemes).[10]

---

9 See McCarthy 1993, 1994, Kiparsky 1994, Cho 1995, Orgun 1995 for counterfeeding in Optimality Theory. The alternation he analyzes is almost identical to the one here. The two-level approach of Orgun 1995 is the only one among these analysis that is compatible with Monotonic Cyclicity. See Krieger, Pirker and Nerbonne 1993 for an approach to phonology in an AVM-based formalism that can handle counterfeeding, and is compatible with Monotonic Cyclicity as well.

10 This statement allows the possibility of a “root cycle” which could add structure to (some of) the terminal nodes in a structure-filling manner (thus not violating the global monotonicity of the formalism). Such an extension is indeed necessary to account for the Turkish facts in this paper.

(22)

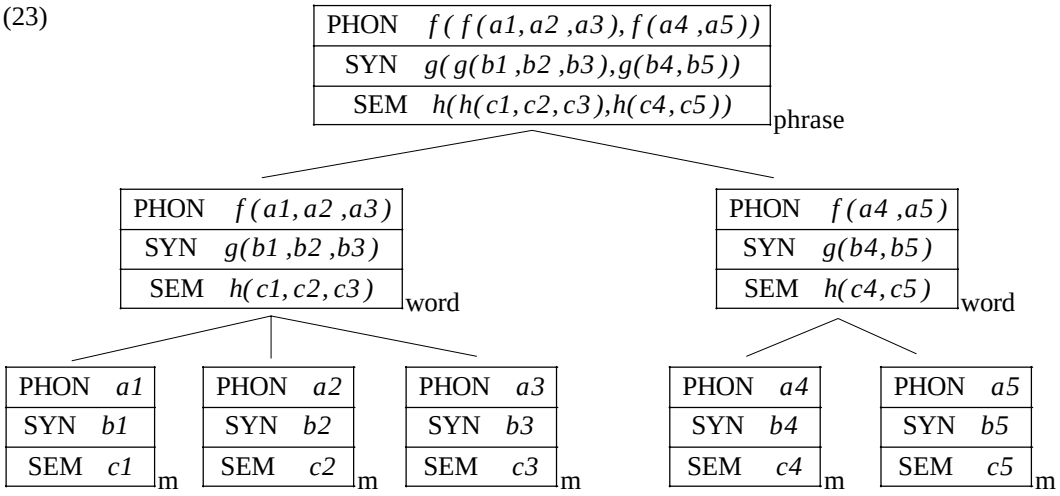


It follows from this representation that any branching structure will potentially exhibit cyclic effects, since the output of one instance of the phonological mapping is input to another instance in branching structures.

3.2 Analogy with Phrase Structure Grammars

In unification based theories of syntax e.g., Gazdar et al 1985, Pollard and Sag 1992, Fillmore and Kay 1995) it is assumed that each node of the (syntactic) phrase structure tree is a feature structure. To determine the mother node in such a tree, it is necessary and sufficient to know the daughter nodes' feature structures, and the phrase structure rule (or construction) that combines them. It is tacitly assumed in most unification based theories that the feature structures associated with nodes in the constituent structure carry phonological, as well as syntactic and semantic information. This assumption is made explicit in Bird 1990,[11] as shown below in example (23) (figure 1-21 from Bird 1990):

(23)



The main purpose of this paper is to derive cyclic phonological effects from such a representation,[12] and to argue for the superiority of this approach over past attempts to handle cyclic phonology in a nonderivational framework.

3.3 Some details of Monotonic Cyclicity

Following Inkelas 1990 and others, I represent affixes as partial constituent structure trees. Given my assumptions concerning the correlates of each node of the tree, this gives rise to the

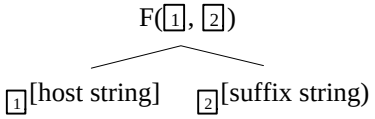
---

11 Bird, however, does not discuss the phonology-morphology interaction, and does not notice that cyclic phonology is an automatic consequence of the model he assumes.

12 Bird's figure incorporates certain assumptions that are not necessary for my arguments here. In particular, the theory I am proposing here is consistent with multiplanar representations (e.g., Sadock 1991, Inkelas 1990).

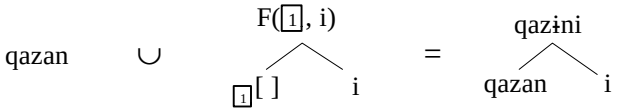
representation in (24), where the suffix string is a constant, and the host string is not specified (although there may be requirements imposed on it).

(24) Proposed representation of affixes[13]



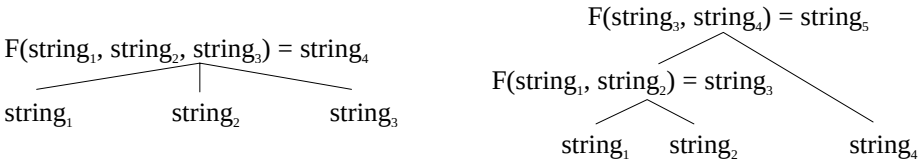
Affixation can now be seen as the unification of a host (which may itself be morphologically complex) with the host string position in (25). I take for granted the existence of a theory of morphology that builds the proper constituent structure tree.

(25) Affixation is unification



This approach derives not only cyclicity, but, provided flat structures are allowed, noncyclicity as well (cf. Mohanan and Mohanan 1984, Halle and Mohanan 1985, Mohanan 1986, where (non)cyclicity has to be stipulated for individual affixes or phonological levels).

(26)



Since no proper subset of the daughter strings in (26) forms an exclusive phonological domain, no cyclic effects are observed (Cole and Coleman 1993 derive cyclic versus noncyclic domains from flat versus branching structures in a similar way).

I now briefly present a case that crucially requires noncyclicity as well as cyclicity. Some speakers of Turkish impose a disyllabic minimal size condition on derived forms (Itô and Hankamer 1989, Orgun and Inkelas 1992).

(27)	*ye-n	‘eat-pass’	yut-ul	‘swallow-pass’
	*do-m	‘my (musical note) do’	sol-üm	‘my (musical note) sol’

The forms on the left hand side are ungrammatical due to prosodic minimality rather than pragmatic anomaly, as illustrated by the grammaticality of the semantically similar disyllabic forms on the right hand side.

Some, but not all, minimality violations may be repaired by adding further suffixes.

(28)	ye-n-ir	‘eat-pass-imprf’	*do-m-u	‘my (musical note) do-acc’
	ye-n-di	‘eat-pass-past’	*do-m-dan	‘my (musical note) do-abl’

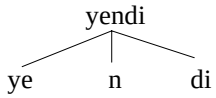
The analysis I offer is as follows: Root, passive, and aspect morphemes form a flat structure, giving rise to noncyclic phonology (no intermediate stem is subject to minimality), whereas root, possessive, and case morphemes form a branching structure, which gives rise to cyclic phonology (the root and possessive combination is subject to minimality, which it violates). The

---

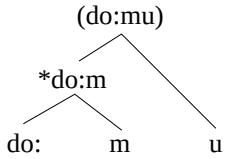
13 The boxed indices indicate identity.

contrast between cyclic and noncyclic application of the minimal size condition results in the appearance of repair for only some minimality violations.

(29) Flat structure = noncyclicity



Branching structure = cyclicity[14]



Thus, the model I propose derives both cyclic and noncyclic phonology without stipulation. Furthermore, it does so without adding any complexity to the theory of grammar: All the intermediate phonological strings in the representations I propose are phonological correlates of morphological or syntactic constituents that we need independently of phonological reasons. Therefore, this approach does not achieve monotonicity by simply multiplying phonological representations to include all intermediate forms (as it may at first appear to), but rather uses independently required syntactic and morphological structure to encode phonological information. This approach is in fact a virtual necessity once we realize that a theory of grammar will have to include not just phonology, but morphology, syntax, etc. as well. Consider the two- and three-level models of Karttunen, Lakoff, and Goldsmith. The input to the phonological mapping in those models includes morphological and syntactic information (encoded as SPE-style morpheme boundary symbols). But this presupposes that the morphosyntactic and phonological modules are temporally ordered with respect to each other, such that the input to the phonological module is a complete morphosyntactic structure. This is blatantly against the desire for nonderivationalism. The model I propose, however, does not commit us to any particular order of operations, and is thus a truly nonderivational one.[15]

---

[14] The node that is indicated as **do:m* in this tree is understood to be undefined. This result can be achieved elegantly in Optimality Theory: Given the relevant constraint set, the optimal parse for the input *do: + m* is the "null parse" (see McCarthy and Prince 1993). To my knowledge, Optimality Theory is currently the only phonological theory that is capable of offering a principles account of such effects.

[15] This discussion should make the intended referent of the word "monotonic" clear. According to my account, the mapping from underlying phonological strings to surface strings need not be monotonic (of course, everyone agrees that the mapping from phonological representations to actual phonetic (i.e., acoustic in spoken languages and gestural in sign languages) output is not necessarily monotonic). The essence of my proposal is that it is in fact incoherent to expect this mapping to be monotonic once one takes into account the necessity of morphosyntactic structure, and its interaction with phonology. An analogy from syntax may be the of help here. Consider the following verb phrase (the actual features used are not relevant to the discussion here):

$[_{\text{cat v, bar 2}}$ [$[_{\text{cat v, bar 0}}$] $[_{\text{cat n, bar 2}}$]]

The fact that the [cat n] feature of the nonhead daughter is not found on the mother node is irrelevant to the monotonicity of the theory. Of course, in terms of the language it defines, such a grammar, if properly formulated, will be equivalent to a context free rewrite system. My proposal in this paper then amounts to claiming that cyclic effects (including those involving loss of underlying information) are expected, and not theoretically troublesome given a general theory of grammar including morphology and syntax. As Cole and Coleman 1993 observe, it can still be ensured that the resulting system will define a context free language, provided the phonological mapping used is regular (finite state).

4. Conclusions

Cyclic effects in phonology cannot be reduced to alignment, or the interaction between a fixed number of parallel representations. The number of applications of phonology must depend on the morphological structure.

Cyclicity is not inconsistent with nonderivational phonology. In fact, given a theory of phonology that does not shortsightedly ignore morphology and syntax, cyclic effects in phonology are inevitable.

Although Goldsmith 1993 and Lakoff 1993 claim that their theories are cognitively real, it is not clear what kind of cognitive evidence there is for their intermediate representations. By contrast, all intermediate representations in the theory I am proposing correspond to some well defined morphological constituent, and, as such, their cognitive reality is unchallenged.

Acknowledgments

Many thanks to Cleo Condoravdi, Charles Fillmore, Sharon Inkelas, Dan Jurafsky, Paul Kay, Jean-Pierre Koenig, Christopher Manning, and the NELS 24 audience, as well as the attendees of a phonology workshop at Stanford on 12/7/1993, where I presented a version of this paper, for comments and questions.

References

Bird, Steven. 1990. *Constraint-based phonology*. University of Edinburgh dissertation.

Cole, Jennifer S. 1990. Arguing for the phonological cycle: A critical review. FLSM 1.

Cole, Jennifer S. and John Coleman. 1993. Cyclic phonology with context-free grammars. Technical report UIUC-BI-CS-92-06, University of Illinois.

Fillmore, Charles J. and Paul Kay. 1993. Construction Grammar. U. C. Berkeley manuscript.

Gazdar, Gerald, Ewan Klein, Geoffrey K.. Pullum and Ivan Sag. 1985. Generalized Phrase Structure Grammar. Cambridge, Massachusetts: Harvard University Press.

Goldsmith, John. 1993. Harmonic Phonology. In J. Goldsmith (ed.), *The Last Phonological Rule.* U. of Chicago Press. 21-60.

Goldsmith, John. 1993b. *The last phonological rule.* The University of Chicago Press.

Halle, Morris and K. P. Mohanan. 1985. The segmental phonology of Modern English. Linguistic Inquiry 16, 57-116.

Hargus, Sharon. 1993. Modeling the phonology-morphology interface. In Hargus, S. and E. Kaisse (eds.), *Phonetics and Phonology, v4,: Studies in Lexical Phonology.* San Diego: Academic Press.

Inkelas, S. 1990. *Prosodic Constituency in the Lexicon. Doctoral* dissertation. Garland Publishing, Inc., New York.

Inkelas, Sharon and C. Orhan Orgun. 1993. Turkish coda devoicing: a prosodic constraint on extrametricality. Presented at the LSA meeting, Los Angeles.

Inkelas, Sharon. 1993. Deriving cyclicity. In Hargus, S. and E. Kaisse (eds.), *Phonetics and Phonology, v4,: Studies in Lexical Phonology.* San Diego: Academic Press.

Itô, Junko and Jorge Hankamer 1989. Notes on monosyllabism in Turkish. In J. Itô and J. Runner (eds.), *Phonology at Santa Cruz*, vol. 1. Syntax Research Center, University of California, Santa Cruz. pp. 61-70.

Johnson, C. Douglas. 1972. *Formal aspects of phonological description.* The Hague: Mutton.

Kaisse, Ellen. 1986. Locating Turkish devoicing. *Proceedings of WCCFL 5.* Stanford Linguistics Association.

Karttunen, Lauri. 1993. Finite-State Constraints. In J. Goldsmith (ed.), *The last phonological rule.* The University of Chicago Press.

Kiparsky, Paul. 1982. Lexical Morphology and Phonology. *Linguistics in the Morning Calm.* Hanshin, Seoul. 3-91.

Kiparsky, Paul. 1993. Blocking in nonderived environments. In Hargus, S. and E. Kaisse (eds.), *Phonetics and Phonology, v4,: Studies in Lexical Phonology.* San Diego: Academic Press.

Lakoff, G. 1993. Cognitive Phonology. In J. Goldsmith (ed.), *The Last Phonological Rule.* U. of Chicago Press. 117-145.

Mascaró, Joan. 1976. *Catalan phonology*. Doctoral dissertation, Massachusetts Institute of Technology.

McCarthy, John. 1993. The Parallel advantage: containment, consistency, and alignment. Rutgers Optimality Workshop 1.

McCarthy, J. and A. Prince. 1993. Generalized alignment. University of Massachusetts, Amherst and Rutgers University ms.

Mohanan, K. P. 1982. *Lexical phonology*. Doctoral dissertation, Massachusetts Institute of Technology. Distributed by the Indiana University Linguistics Club.

Mohanan, K. P. 1986. *The theory of lexical phonology.* Dordrecht: Reidel.

Mohanan, K. P. and Tara Mohanan. 1984. Lexical phonology of the consonant system in Malayalam. Linguistic Inquiry 15.575-602.

Orgun, O. and S. Inkelas. 1992. Turkish prosodic minimality. 6th International Conference on Turkish Linguistics, Anadolu U.

Pesetsky, David. 1979. Russian Morphology and Lexical Theory. unpublished manuscript, Massachusetts Institute of Technology.

Pollard, Carl and Ivan Sag. 1982. *Head Driven Phrase Structure Grammar*. University of Chicago Press.

Poser, William. 1989. The metrical foot in Diyari. *Phonology* 6.117-148.

Prince, A. 1985. Improving tree theory. *BLS* 11.471-490.

Prince, A. and P. Smolensky. 1993. Optimality theory. Rutgers U. and the U. of Colorado, Boulder ms.

Rice, Keren. 1990. Predicting rule domains in the phrasal phonology. In S. Inkelas and D. Zec (eds.), *The phonology-syntax connection.* CSLI Publications and the University of Chicago Press. 289-312.

Sadock, Jerrold M. 1991. *Autolexical Syntax.* The University of Chicago Press.

Scobbie, James M. 1991. Attribute value phonology. University of Edinburgh dissertation.

Sezer, Engin. 1985. An autosegmental analysis of compensatory lengthening in Turkish. In Wetzels, L. and Sezer, E (eds.), *Studies in compensatory lengthening.* Dordrecht: Foris Publications.

Sproat, R. 1985. On deriving the lexicon. MIT dissertation.

A slightly shorter version of this paper was presented at NELS 24. This version may be cited as a U. C. Berkeley manuscript dated 1994. Comments are welcome.

Orhan Orgun orgun@cogsci.berkeley.edu Linguistics, UC Berkeley, CA 94720-2650