Sign-Based Morphology: a declarative theory of phonology-morphology interleaving
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1. Introduction

This paper[1] investigates the implications of cyclic phonological effects for nonderivational theories of phonology, and proposes a declarative theory of the phonology-morphology interface called Sign-Based Morphology that accounts for such effects. The term "cyclicity" refers to the state of affairs in which a subpart of a linguistic form may be subject to phonological constraints on its own, in addition to constraints enforced on the whole form. There may be a number of such embedded phonological domains in morphologically complex forms. The number and location of such domains is determined by the morphological structure. There are two common ways in which cyclicity has been implemented in theories of phonology. These are summarized in (1) and (2).

(1)   Phonology applies to fully formed morphological structures. Most deeply embedded constituent undergoes phonology first, phonology then applies to successively larger constituents: SPE, Halle and Kenstowicz 1991, Halle and Vergnaud 1987, Odden 1993.

(2)   Inputs to some morphological constructions may be subject to phonology on their own (interleaving): Lexical Phonology (Pesetsky 1979, Kiparsky 1982, 1983, 1985; Mohanan 1982, 1986), Prosodic Lexical Phonology (Inkelas 1990).

Theories such as Lexical Phonology (Pesetsky 1979, Kiparsky 1982, Mohanan 1982, 1986) have made a distinction between two kinds of phonology-morphology interleaving: cyclicity and level ordering. In this paper, the term "interleaving" covers what is traditionally called cyclicity as well as what is traditionally called level ordering. The difference between cyclicity and level ordering will not be relevant.[2]

2. Cyclicity in the age of nonderivationalism

In this section I discuss the implications of the rise of nonderivational phonology for the analysis of apparently cyclic phenomena.

2.1 Background: nonderivational approaches to phonology

Recent years have witnessed a growing movement towards nonderivational approaches to linguistics. The first strictly declarative approach to phonology was proposed by Johnson (1972), who launched the small but healthy field of declarative phonology based on finite state transducers, represented by such works as Koskenniemi 1983, Kaplan and Kay 1981. More recently, monostratal constraint-based approaches to phonology have been proposed by such researchers as Bird 1990 and Scobbie 1991. However, it is only during the past few years that constraint-based nonderivational approaches such as Harmonic Phonology (Goldsmith 1989), the Theory of Constraints and Repair Strategies (Paradis 1988) and Optimality Theory (Prince and Smolensky 1993) have come to dominate the field.

Constraint-based theories of phonology have largely focused on the phenomena once believed to motivate rule ordering, demonstrating that work earlier attributed to derivation can

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[2]   Detailed discussion of the status of level ordering in Sign-Based Morphology can be found in Orgun 1994a,b and Inkelas and Orgun 1995a,b.

be handled by nonderivational theories as well. However, the status of cyclic phonology remains somewhat less clear. The present paper is devoted to exploring this issue.

2.2 Cyclicity as a problem for nonderivational phonology

Many proponents of nonderivational phonology summarily equate cyclic phonology with rule ordering. For example, Goldsmith summarizes the operation of the phonology-morphology interface in Lexical Phonology (Pesetsky 1979, Kiparsky 1982, Mohanan 1982, 1986): "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" (1993:21). The presupposition here is clear: cyclicity is intrinsically derivational. Under this view, development of a true nonderivational approach to phonology requires finding alternatives to cyclicity. The sample slogans below illustrate this and some other common reactions to interleaving.

(3)   "Interleaving is not necessary" (Lakoff 1993, Karttunen 1993, Kennedy 1994, Myers 1994, Zec 1994, Cole 1991, Cole and Coleman 1993)

(4)   "Interleaving is a device every analysis should try to do without" (Lakoff 1993, Karttunen 1993, McCarthy and Prince 1993, Kennedy 1994, Myers 1994, Zec 1994, Benua 1995, McCarthy 1995, Kenstowicz 1995)

(5)   "Interleaving is cognitively implausible" (Goldsmith 1993, Lakoff 1993)

(6)   "Interleaving is computationally intractable" (Sproat 1992)

(7)   "Interleaving is inherently derivational" (Bird 1990, Scobbie 1991, Lakoff 1993, Karttunen 1993, McCarthy and Prince 1993, Kennedy 1994, Myers 1994, Zec 1994, Benua 1995, McCarthy 1995, Kenstowicz 1995, etc.)

2.3 Doing without cyclicity

The common stance among nonderivational phonologists is, as we have seen, that interleaving is inconsistent in spirit (as well, presumably, as in letter) with a strictly declarative approach to phonology. Some researchers holding this view have optimistically assumed that the demonstrated alternatives to rule ordering will, with little or no modification, account for cyclic effects as well. To take one example, Karttunen (1993) writes in a paper defending a nonderivational approach to phonology that "We have not mentioned the issue of *cyclic* ordering … Let us simply state that, in our opinion, the arguments for cyclic ordering are weaker then the ones [for rule ordering within a cycle] we discuss" (1993:194).

This optimism has proved unwarranted, however, as other, more empirically oriented work has recognized that many cyclic effects prove resistant to reanalysis using the tools developed to replace rule ordering. A number of different approaches have been taken to the challenge posed by cyclic effects. I survey two general classes of approaches in §§2.3.1, 2.3.2.

2.3.1 Cyclic effects are illusory and reducible to other things

Some researchers have claimed that cyclic phonological effects are only epiphenomenal and looked for other mechanisms to derive such effects.

One approach is to multiply the number of levels to which declarative constraints apply. Both Goldsmith (1993) and Lakoff (1993) propose that constraints relate three parallel phonological representations, the (implicit) expectation being that cyclic effects never require more than two cycles of phonology (a claim made independently by Cole (1991)). Another, totally different, line of attack is taken by Prince and Smolensky (1993) and McCarthy and Prince (1994). In this Optimality-theoretic approach, cyclic effects are claimed to reduce to the result of constraints requiring alignment between edges of morphologically defined domains and edges of metrical elements. These two approaches essentially claim that true cyclic effects,

in which there are potentially as many applications of phonology in a complex word as there are morphological subconstituents in the word, are epiphenomenal. What appears to be the application of phonology to a subword constituent is really something else entirely.

What all these approaches share is the view that phonology applies only once to the underlying representations supplied by the morphemes in a linguistic form. Example (8) presents a list of some of the theories based on this assumption:

(8)   Theories assuming a single phonological mapping from UR to surface: Most Structuralist work, Generalized Alignment (McCarthy and Prince 1993), Declarative Phonology (Bird 1990, 1995; Scobbie 1991, 1993; Coleman 1991, 1995), Two-Level Phonology (Johnson 1972, Kaplan and Kay 1981, Koskenniemi 1983, Karttunen 1993), Cognitive Phonology (Lakoff 1993), Harmonic Phonology (Goldsmith 1989, 1991, 1993; Goldsmith and Larson 1990).

2.3.2 Cyclic effects are real but paradigmatic

Another type of approach, represented by Becker 1993, Bochner 1993, Burzio 1994, Steriade 1994, Benua 1995, Buckley 1995, Flemming 1995, Kenstowicz 1995, and McCarthy 1995, admits the validity of evidence for cyclic phonology but proposes an alternative interpretation in which cyclic effects are claimed to follow from correspondence constraints holding between paradigmatically related lexical items. The lexical items in question are not morphologically derived from one another. The correspondence constraints simply relate existing lexical items.

2.4 Cyclicity as nonderivational

All the approaches described so far have taken it for granted that cyclic phonology, like rule ordering, is derivational and that this is sufficient reason to look for alternatives to cyclicity. The approaches vary only in the nature of the alternative they propose.

In this paper, I reject the presupposition underlying these approaches, contending that there is an important distinction between rule ordering and phonology-morphology interleaving. I argue that, contrary to popular belief, there is nothing inherently derivational about the latter.

Similar arguments can be found in two strains of past work. Cole and Coleman (1993) show that interleaving effects can be captured in a monostratal approach to phonology by enforcing declarative constraints on morphologically defined subparts of a phonological string (the approach is similar in this regard to the one taken by Buckley 1995, though there are important differences in implementation).[3] Following a different line of attack, Orgun 1994a,b and Riehemann 1994 propose to integrate two-level approaches to phonology such as Generalized Correspondence Theory (McCarthy and Prince 1994, 1995) with declarative approaches to phrase structure such as HPSG (Pollard and Sag 1987, 1994). Such declarative approaches derive interleaving effects as a direct consequence of their basic architecture. In this paper I build on the approaches of Orgun and Riehemann, developing a full-fledged nonderivational theory of the phonology-morphology interface called Sign-Based Morphology.

Sign-Based Morphology, the theory proposed in this paper, falls into the category in (2). It is a theory of phonology-morphology interleaving. However, it differs from past interleaving approaches in several important ways. First, it is declarative; second, it derives interleaving effects from constituent structure configurations, rather than stipulating them in derivational terms, as past approaches have done.

Any satisfactory theory of the phonology-morphology interface should satisfy (at least) the following criteria. It should:

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[3]   The main difference is that in Cole and Coleman's approach the domains in question are embedded in one another, while in Buckley's approach they are not.

(9)   a. Account for cyclic effects (cases where phonology seems to refer to a morphological subconstituent)
       b. Account for noncyclic effects (cases where phonology seems to fail to refer to morphological subconstituents)
       c. Relate the cyclic-noncyclic contrast to independently motivated aspects of morphological structure

The aim of this paper is to show that Sign-Based Morphology, in addition to being nonderivational, satisfies the criteria above better than existing theories (whether derivational *or* nonderivational) of the phonology-morphology interface.

The paper begins with a section (§3) presenting a number of examples showing the need for interleaving. I then (in §4) present Sign-Based Morphology, a declarative approach to morphology that builds on the findings of Riehemann (1994) and Orgun (1994a,b). In §5 I compare Sign-Based Morphology with current paradigmatic approaches to the phonology-morphology interface, showing that Sign-Based Morphology is superior on both empirical and theoretical grounds. I conclude that whether or not there is a derivational residue in phonology is entirely a question for phonological theory proper. Phonology-morphology interleaving is not a source of derivationalism.

Due to lack of space, I do not take up the cognitive and computational implications of Sign-Based Morphology in this paper. See Riehemann 1994, Jurafsky and Koenig 1994, and Orgun, Koenig and Jurafsky 1996 for discussion.

3. Empirical necessity for interleaving: schizophrenia and sensitivity to branching

The purpose of this section is to show that constraints on intermediate morphological constituents are relevant to the ultimate surface outcome — i.e. that interleaving is necessary. This conclusion is entirely independent of the particular theory of phonology one assumes. It is also independent of one's particular approach to the phonology-morphology interface.

Although there are many types of phenomena that point to the need for interleaving, I discuss only two here. Section 3.1 presents a case of schizophrenia, the term applied by Orgun (1994c) to cases in which a segment is subject to the constraints of a syllabic position that differs from its surface one, but matches the syllable position of the corresponding segment in a morphologically related form (see Hall 1994 for examples). The particular example to be discussed comes from Uighur, in which certain vowels undergo open syllable raising even though they surface in a closed syllable. Section 3.2 discusses phonological sensitivity to the direction of branching in the morphological constituent structure, as exemplified by continuant voicing alternations in Slave compounds, which apply differently according to whether the constituent structure is left- or right-branching.

3.1 Schizophrenia

Schizophrenic segments include consonants that are subject to coda neutralization even though they are in a surface onset (Turkish; Orgun 1994b, Inkelas and Orgun 1995a), vowels that undergo closed syllable laxing even though they are in a surface open syllable (Javanese; Hargus 1993), or, as in the Uighur example here, vowels that undergo open syllable raising even though they are in a surface closed syllable. Schizophrenia requires interleaving because the conditioning for the alternation in question is not present in the surface form. The constraint (or rule) must have applied in a morphologically related form, which the surface form is derived from (or related to).

Schizophrenia arises in Uighur (Orgun 1994b, cf. Buckley 1995) through the interaction of vowel raising and elision. The first alternation, raising, applies to vowels in stem-final open syllables when followed by a suffix (i.e., it does not apply word-finally). Although it

applies to all nonhigh vowels in Uighur (/a,e,o,ø/), I only illustrate it applying to /a/, which raises to /ɨ/:[4]

(10) Plain noun (no raising)   Suffixed noun (raising applies)

    qazan   'pot'   qazɨn-i   'pot-POSSESSIVE'

    kala   'cow'   kalɨ-ɣa   'cow-DATIVE'

    tuxa   'chicken'   tuxɨ-dan   'chicken-ABLATIVE'

    bala   'child'   balɨ-si   'child-POSSESSIVE'

    ana   'mother'   anɨ-lar   'mother-PLURAL'

    ameriqa 'America'   ameriqɨ-da 'America-LOCATIVE'

The second alternation of interest is elision of high unrounded vowels between identical consonants when permitted by syllable structure (i.e., in two-sided open syllable environments). The alternation illustrated in (11) is $ɨ \rightarrow \varnothing$, although /i/ also undergoes elision. The double-underlined vowel in the input is the one which deletes in the output:

(11) balɨlar + i   →   ballɨri   'child-PL-POSSESSIVE'

    balɨlar + i + ni   →   ballɨrɨni   'child-PL-POSSESSIVE-ACC'

    kalɨlar + ni   →   kallarni   'cow-PLURAL-ACC'

Schizophrenia arises through the interaction of raising with elision. Through elision, a vowel that has undergone open syllable raising may end up in a surface closed syllable. The schizophrenic vowel in (12) is double-underlined:.

(12) qazan + i + ni →   qazɨnni   'pot-POSSESSIVE-ACC'

The question at hand is: Why is the underlined vowel high? Note that the corresponding vowel in the form *qazan + ni → qazanni* 'pot-ACC' is low.

      Interleaving provides a simple answer to this question: N+POSS+CASE is morphologically derived from (or related to) N+POSS. In particular, *qazɨnni* (12) is derived from (or related to) *qazɨni*

(10). The reason *qazɨnni* has a high vowel is that the phonological form which is input to this particular morphological form itself has a high vowel, as illustrated below:

(13)   qazan   'pot'

    qazan + i   →   qazɨni   'pot-POSS'

    qazɨni + ni   →   qazɨnni   'pot-POSS-ACC'

Many more examples of schizophrenia can be found in Hargus 1993, Hall 1994 and Orgun 1994c, where interleaving accounts are also offered.

3.2 Sensitivity to the direction of branching: Slave continuant voicing alternations

The second type of evidence for interleaving is presented by phonological alternations which apply differently to left- and right-branching morphological structures. Tone sandhi is particularly rife with effects of this type; see, for example, Shih 1986 and Sproat 1992 for discussion of Mandarin tone sandhi. The example I present here, however, involves continuant voicing alternations in Slave. The data are from Rice 1988, 1989. The analysis closely follows that in Rice 1988, except for Rice's theory-internal considerations of underspecification.

      Example (14) contrasts possessed and nonpossessed forms of nouns. The alternation of interest is that noun-initial continuants, voiceless in the nonpossessed forms, are voiced in the possessed forms. (Other alternations, with which we are not concerned here, also occur in

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[4]   All the transcriptions in this paper are given in IPA, except that [a] is used in place of [ɑ].

these data, namely: coda consonants other than [n] neutralize to [h]; coda [n] deletes with concomitant nasalization of the preceding vowel.)

(14) Possessed nouns with voiced initial continuants (Rice 1988: 376)

Nonpossessed	Possessed	
ʃį̀	gah ʒin-é	'(rabbit's) song'
	se-ʒin-é	'my song'
ɬuh	dezonah luz-é	'(child's) spoon'
	se-luz-é	'my spoon'

The voicing alternation observed in (14) also occurs in what Rice calls type 1 compounds. These are highly lexicalized compounds, which differ from Rice's type 2 in semantic as well as phonological aspects (see Rice 1988 for discussion). As illustrated in (15), the initial continuant of a noun in isolation or of the first member of a type 1 compound is voiceless, while the initial continuant of the second member of a type 1 compound is voiced. The boldfaced continuants in (15) alternate in voicing according to their position in word structure:

(15) "Type 1" compounds with voiced initial continuants (Rice 1988:186, Rice 1989:376)

kw'ih	'mosquito'	ʍé	'skin'	kw'ih-wé	'mosquito netting'
sah	'bear'	θeh	'skin'	sah-ðeh	'bearskin'
tenih	'pot'	séh	'hook'	tenih-zél-é	'pot handle'

The true sensitivity of these voicing alternations is best illustrated by the behavior of three-morpheme structures, including (right-branching) possessed two-member compound nouns as well as (left-branching) three-member compounds.

Example (16) illustrates possessed and nonpossessed forms of compound and noncompound nouns. The contrast of interest occurs in the possessed forms: the initial continuant of a noncompound noun is voiced when the noun is possessed, but the initial continuant of a compound noun is voiceless in the same environment. The failure of voicing to apply in possessed compounds is not due to an idiosyncratic property of the noun stems in question: observe, in each of (i-iii), that the initial continuant of the same stem in isolation will undergo voicing when possessed. The alternating continuants are shown in boldface:

(16) Failure of voicing to apply to possessed compound nouns (Rice 1989:34, 189, 190)

	Nonpossessed	Possessed	Gloss
i)	sa-dzeé	se-sa-dzeé	'(my) watch, clock'
cf.	sa	se-za-á	'(my) sun, month'
ii)	ɬeh-t'éh	se-ɬéh-t'éh-é	'(my) bread'
cf.	ɬéh	se-léz-é	'(my) flour'
iii)	sah-ðeh	se-sah-ðéh-é	'(my) bear skin'
cf.	sah	se-zah-é	'(my) bear'

Moreover, it is not a general fact that the second morpheme in a three-morpheme word will fail to undergo initial continuant voicing. In (left-branching) three-member compounds, the (boldfaced) initial continuants of both the second and third stems undergo voicing:

(17) Voicing applies in left-branching compounds (Rice 1989:186, 187)

da	'face'	xá	'hair'	bee	'knife'	da-ɣá-bee	'razor'
						cf. da-ɣá	'beard'
deʃį	'wood'	tée	'mat'	ʍé	'skin'	deʃį-té-wé	'rug'
tsá	'beaver'	ʍé	'skin'	detʃin	'stick'	tsá-wé-detʃin-é	'stretcher for furs'

The behavior of the complex words in (16) and (17) makes sense once morphological constituent structure is taken into account. The generalization is illustrated in (18): Voicing applies to the second and third stems in a left-branching compound, but only to the second stem in a right-branching compound.

(18) Sensitivity of voicing to direction of branching (input continuants [∅voice])

Rice (1988) exploits this generalization by presenting a cyclic analysis of these data, which I will closely follow here. However, I will depart from Rice's theory-internal choices regarding underspecification, and, in so doing, better capture the relationship between the cyclic voicing alternations and the treatment of underlying specification of either value for the feature [voice].

The essence of Rice's analysis is that, on each cycle, domain-initial continuants are voiced, while domain-internal ones are devoiced (one can assume either that there is no root cycle, or, like Rice, that the voicing alternations are not active on the root cycle). Crucially, voicing alternations are structure-filling in Rice's analysis, allowing any input voicing specifications to be kept. Voicing alternations apply only to those continuants that are unspecified for voicing in the input.

(19)   Cyclic analysis of Slave facts:
- On each cycle, domain initial continuants are devoiced; other continuants are voiced.
- (De)voicing is structure-filling (it applies only to continuants that are not specified for voicing in the input—it is a default).

These two assumptions are sufficient to account for the Slave data we have seen, as the derivations in (20) show. Upper case letters indicate segments that are unspecified for voicing:

(20)   Cyclic generation of left- and right-branching structures.

	[Se [Sa dzeé]]	[Se Saá]	[[da Xá] bee]	[[deʃin té] Wé]
Cycle 1	sadzeé	sezaá	daɣá	deʃi̧té
Cycle 2	sesadzeé	—	daɣábee	deʃi̧téwé

The crucial assumption that voicing alternations are structure-filling makes an important prediction: underlying voicing specifications should be respected as well. That is, underlyingly voiceless initial continuants (if any) should always surface as voiceless, regardless of morphological structure; likewise, any underlyingly voiced initial continuants should always surface as voiced. Both predictions turn out to be correct, as shown below:[5]

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[5]   The present analysis differs from Rice's at this point. Rice assumes a theory of underspecification that does not allow [-voice] to be specified underlyingly, forcing her to treat consistently voiceless continuants as exceptions. (In a few of the cases, Rice proposes that the form in question has a compound structure, in order to provide a source for the input [-voice] specification to the voicing alternation, even though there is no nonphonological evidence for this claim.) The analysis here has the virtue of unifying the behavior of underlying specifications with derived ones. That is, the analysis is sensitive to what information is present in a given form, but insensitive to where that information has come from.

(21)   Support: *Underlying* voicing specifications are also respected.

Consistently voiced		Consistently voiceless		
Nonpossessed	Gloss	Nonpossessed	Possessed	Gloss
jah	'snow'	sǫ́	se-sóné	'(my) excrement'
ledʒai	'window'	ɬe	se-ɬé	'(my) lard'
zǫ	'only'	sámbaa	se-sámbaa	'(my) money'
jú	'clothes'	satsoné	se-satsoné	'(my) stove'
ladíʔǫ	'thimble'	sǫ́ba	se-sǫ́ba	'(my) money'

The assumption that voicing is structure-filling allows us to capture a generalization over underlying forms and morphologically complex ones. In both cases, input voicing specifications are respected by further morphology.

(22)   Generalization: Input voicing specifications are respected.

A cyclic, structure-filling account nicely captures the intrinsic relationship between the sensitivity to the direction of branchingness and the preservation of underlying voicing specifications. This insight is not available in a noncyclic account. At best a noncyclic account could mimic the cyclic account by making the following brute-force stipulations:

(23)   a.   Underlying voicing specifications are respected (thus handling the data in (21))
          b.   The initial continuant of each branching node is voiceless (capturing the generalization in (18))

However, these stipulations are not intrinsically connected on the noncyclic account. This is unfortunate, as it misses the generalization that the behavior of structure of a given type (in this case, [±voice]) is the same whether the structure is underlying or derived[6].

　　　Having demonstrated the need for interleaving, we are now ready to develop a theory of phonology-morphology interaction that incorporates interleaving.

4. Sign-Based Morphology
In this section I develop a theory of the phonology-morphology interface, called Sign-Based Morphology, which draws upon two different lines of work. The first is the structural approach to interleaving proposed (in slightly different forms) by Sproat 1985, Cohn 1989 and Inkelas 1990, 1993a. The second is the unification-based approach to grammar, especially the line of work represented by Kay 1983, Gazdar et al. 1985, Pollard and Sag 1994, Fillmore, Kay and O'Connor 1988, Kay and Fillmore 1994, Koenig 1992, 1993, and Koenig and Jurafsky 1994. The theory I develop is one in which interleaving follows as a natural and inevitable consequence of constituent structure, thus overcoming past objections to interleaving as an extraneous device which phonological theory should try to eliminate.

　　　I begin with a brief discussion of the difference between "sign-based" and "terminal-based" approaches to linguistics. This is a critical contrast to draw, as past criticisms of interleaving as "extraneous" crucially, if implicitly, assume a terminal-based approach to grammar. In this section, I will demonstrate first that there are no truly terminal-based approaches to linguistics. I will conclude that interleaving effects can be viewed as a

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[6]   The cyclic, structure-filling account has implications for phonology proper as well as for the phonology-morphology interface. In particular, contra recent work in Optimality Theory (especially Smolensky 1993, McCarthy 1994), underspecification is required for descriptive adequacy (see also Inkelas 1994 on this point); furthermore, contrary to claims by Mester and Itô 1989, Lombardi 1991, Steriade 1995, the feature [voice] cannot be privative. [-voice] is crucially necessary (as shown also by Orgun 1994b, Inkelas 1994, Inkelas and Orgun 1995a).

consequence of using constituent structures. Objections to interleaving only make sense if constituent structures are to be dispensed with as well.

In the terminal-based approach, which underlies work in the Structuralist tradition, terminal nodes are the only information-bearing elements in a constituent structure. The sole role of nonterminal nodes is to organize the terminal nodes into groups. The meaning of a linguistic form is assembled from the semantic information in the terminal nodes, while the phonology is determined by some phonological system operating on the strings supplied by the terminal nodes, which are the underlying representations of the morphemes that occupy those nodes. The status of phonology in this kind of model is illustrated in (24) for the Slave form *dezonahsahðehé* 'child's spoon'.

(24)   "Terminal-based" approach

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                    N
                    |
                     \
                        N
                       / \
        N          N        N
        |          |        |
     dezonah     Sah      Θehé         ⇒      [dezonahsahðehé]
   (  dezonah     Sah      Θehé  )
```
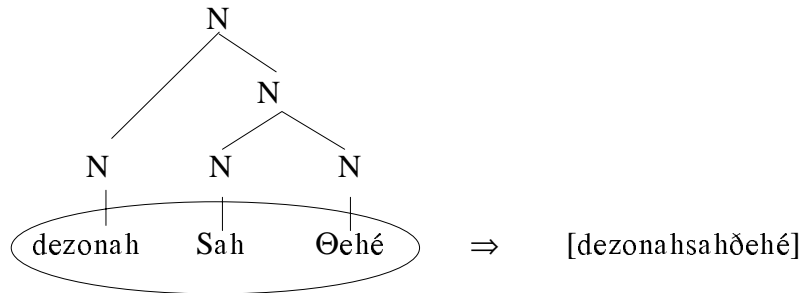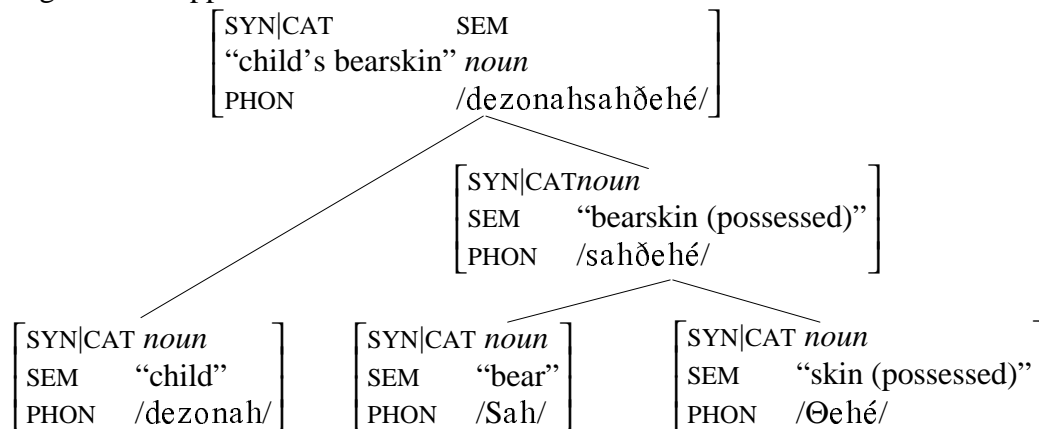
The only way to generate cyclic effects in such a model is by stipulating, as in SPE, that phonology is applied to successively larger constituents. Clearly, this is a derivational model of cyclicity. All past and current criticisms of cyclic phonology of which I am aware are based on this understanding of cyclicity.

Sign-based theories of linguistics differ from terminal-based ones in assuming that every node in a constituent structure, including nonterminal nodes, is an information-bearing element. That is, nonterminal nodes as well as terminal ones carry syntactic, semantic, and phonological information. The following discussion of sign-based linguistics highlights what is important for the purposes of this paper (for a more detailed general introduction, see Shieber 1986 and Pollard and Sag 1994).

A "sign" is defined as a Saussurean pairing between some phonological shape and some semantic information. In sign-based theories, a constituent structure is a statement of how the grammar justifies (licenses) the sign represented by the top node. Example) shows a sign-based representation of the same Slave form *dezonahsahðehé* 'child's spoon' whose terminal-based representation was given in (24). The syntactic and semantic features are highly abbreviated for clarity.

(25)   "Sign-based" approach

$$\begin{bmatrix} \text{SYN|CAT} & \text{SEM} \\ \text{"child's bearskin"} \; noun \\ \text{PHON} & /\text{dezonahsahðehé}/ \end{bmatrix}$$

$$\begin{bmatrix} \text{SYN|CAT} noun \\ \text{SEM} & \text{"bearskin (possessed)"} \\ \text{PHON} & /\text{sahðehé}/ \end{bmatrix}$$

$$\begin{bmatrix} \text{SYN|CAT} \; noun \\ \text{SEM} & \text{"child"} \\ \text{PHON} & /\text{dezonah}/ \end{bmatrix} \quad \begin{bmatrix} \text{SYN|CAT} \; noun \\ \text{SEM} & \text{"bear"} \\ \text{PHON} & /\text{Sah}/ \end{bmatrix} \quad \begin{bmatrix} \text{SYN|CAT} \; noun \\ \text{SEM} & \text{"skin (possessed)"} \\ \text{PHON} & /\text{Θehé}/ \end{bmatrix}$$
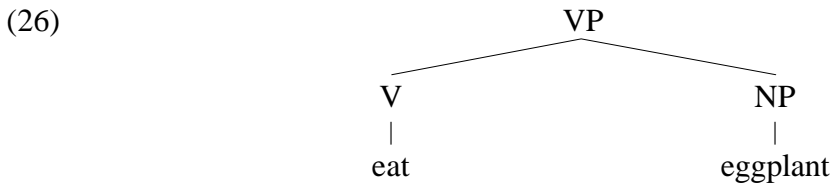
The proper interpretation of the sign-based constituent structure in (25) is the following, which is fashioned after Kay 1983: The sign [dezonahsahðehé] is a possible pairing of form and meaning in Slave for the following reasons: i) the signs [dezonah] and [sahðehé] exist, and ii) the grammar allows, given a nominal sign and a possessed nominal sign, for there to be another nominal sign that combines the forms of the possessed nominal and noun in some appropriate way (to be dealt with by phonological theory) and inherits appropriate semantic information from the possessed noun and possessor noun. Constituent structures thus have a dual interpretation: they can be seen as representing the internal part-whole structure of a sign (the syntagmatic interpretation), or as a statement of what in the lexicon and grammar makes it possible to have the sign represented by the top node (the paradigmatic interpretation).

In a sign-based approach, the features of a mother node must be related to the features of its immediate constituents. This relation can be controlled by a set of constraints. Since these constraints apply to the phonological string of each node in a given constituent structure, complex constituent structures automatically give rise to interleaving effects. For example, the failure of continuant voicing to apply to the *sah* portion of the top node in) is due to the fact that the intermediate constituent *sahðehé* is subject to phonological constraints which require its initial continuant to be voiceless.

Most work in linguistics implicitly assumes a terminal-based approach; theories which are explicitly sign-based are a distinct minority. However, this contrast is in fact illusory. I am aware of no linguistic theory since Structuralism which attributes no information to nonterminal nodes. *All* current constituent-based approaches to linguistics use some kind of feature percolation, thereby locating at least some information on the nonterminal nodes. The fact that nonterminal nodes bear category features is enough to illustrate this point. For example, in the constituent structure in (26), the category label of the mother node is the same as the category label of the head daughter, an instance of head feature percolation.

(26)

```
                    VP
          ┌─────────┴─────────┐
          V                   NP
          │                   │
         eat               eggplant
```

The need for assigning featural information to nonterminal nodes in a constituent structure was recognized even within the Structuralist tradition by Hockett 1954, who observed that a pure item-and-arrangement view (a pure terminal-based approach in the terminology I use here) is therefore untenable.

The following quote from Pinker 1994 makes even clearer the convenience and appeal of feature percolation, an articulated theory of which can be found in Lieber 1980:

(27)   "Take the English noun phrase. A noun phrase (NP) is named after one special word, a noun, that must be inside it. The noun phrase owes most of its properties to that one noun. For example, the NP the cat in the hat refers to a kind of cat, not a kind of hat; the meaning of the word cat is the core of the meaning of the whole phrase. Similarly, the phrase fox in socks refers to a fox, not socks, and the entire phrase is singular in number (that is, we say that the fox in socks is or was here, not are or were here), because the word fox is singular in number. This special noun is called the "head" of the phrase, and the information filed with that word in memory "percolates up" to the topmost node, where it is interpreted as characterizing the whole phrase as a whole." [Pinker 1994:106-7]

Although this quotation describes only head feature percolation, some of the features of a nonterminal node will of course depend on non-head daughters as well (e.g. the contrast in definiteness between *the fox* and *a fox*).

Recall from the discussion earlier that percolation is the mechanism that derives interleaving effects in phonology. Since all existing theories of linguistics assume at least some degree of percolation of syntactic features, it is fair to say that the only device needed to derive cyclicity comes for free in all existing theories of linguistics, even if they are not explicitly stated as sign-based.

Thus, far from being an extra "tool" that adds complexity to a theory (Zec 1994, Kennedy 1994), interleaving is a direct consequence of using constituent structures. Anyone who is committed to avoiding interleaving must do without constituent structures![7,8]

In order to make this point clearer, consider the following constituent structure from Lieber (1980:90) for the Latin verb form *diksera:mus* 'say.PAST-PERF-1PL' (where "0" means the value of the feature in question is not specified).

(28)

$$
\begin{bmatrix} + & V \\ - & pres \\ + & perf \\ + & pl \\ 1 & pers \end{bmatrix}
$$

$$
\begin{bmatrix} + & V \\ - & pres \\ + & perf \\ 0 & pl \\ 0 & pers \end{bmatrix}
$$

$$
\begin{bmatrix} + & V \\ - & pres \\ 0 & perf \\ 0 & pl \\ 0 & pers \end{bmatrix}
$$

diks	era:	mus

$$
\begin{bmatrix} + & V \\ - & pres \\ 0 & perf \\ 0 & pl \\ 0 & pers \end{bmatrix}
\qquad
\begin{bmatrix} + & V \\ 0 & pres \\ + & perf \\ 0 & pl \\ 0 & pers \end{bmatrix}
\qquad
\begin{bmatrix} + & V \\ 0 & pres \\ 0 & perf \\ + & pl \\ 1 & pers \end{bmatrix}
$$
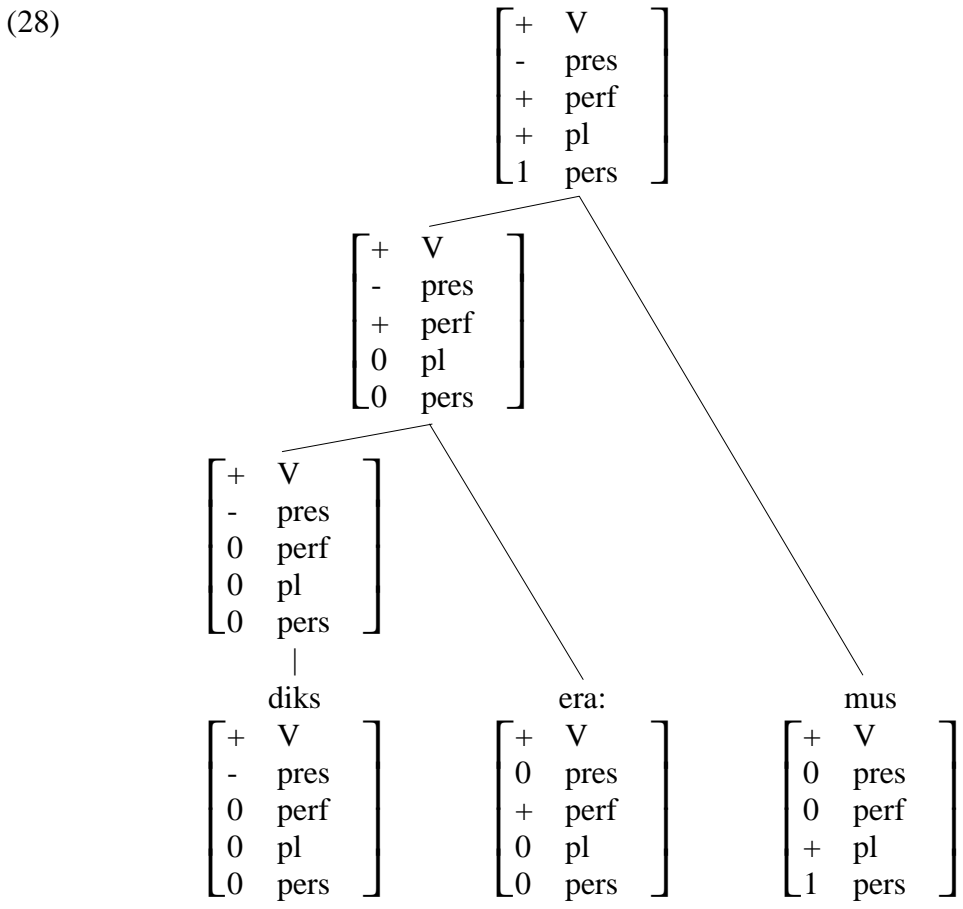
The morphosyntactic and semantic features of each nonterminal node are determined by a number of "feature percolation conventions" in Lieber's approach. In any approach using constituent structures, the feature composition (i.e., category labels as well as other syntactic features such as bar level, and semantic features) of a nonterminal node will be related to the

---

[7] This of course does not mean that constituent structures are required in order to derive interleaving effects. Interleaving is in fact also an automatic consequence of realizational approaches to morphology such as that in Anderson 1992. See Orgun 1995d for a discussion of the relationship between realizational morphology and Sign-Based Morphology.

[8] Becker 1993 makes this same point, and develops a paradigmatic theory of morphology that does not use constituent structures.

features of its immediate constituents through some constraints. By notating this dependency as a function, and using SYN, SEM, and PHON for the syntactic, semantic, and phonological features of a given node, we arrive at the following representation of the Latin verb form, which makes the constraint based nature of the feature composition clearer:

(29)
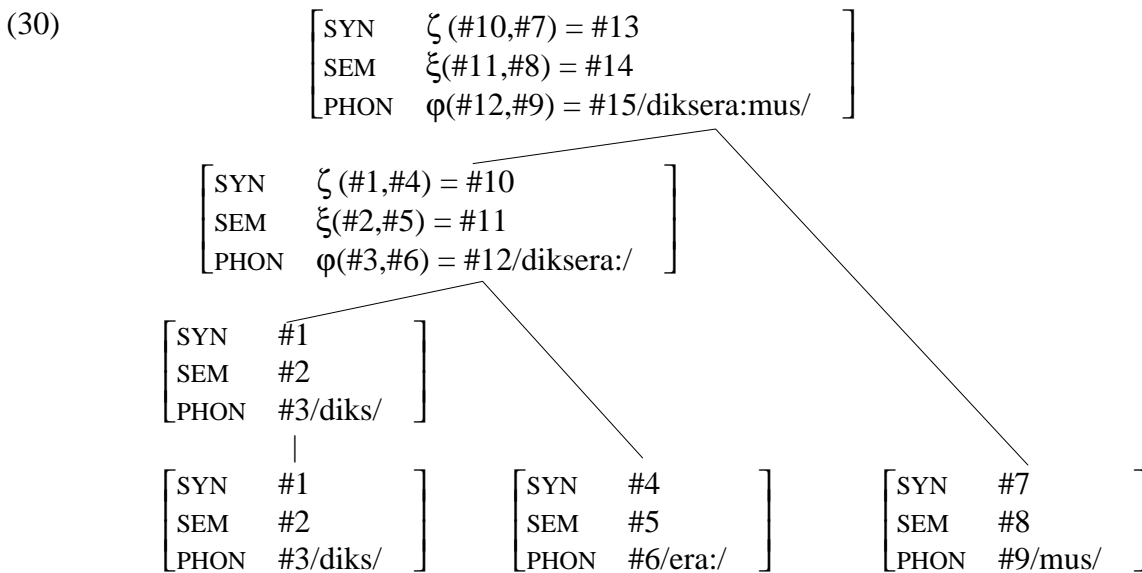$$\begin{bmatrix} \text{SYN} & \zeta\,(\#7,\#5) = \#9 \\ \text{SEM} & \xi(\#8,\#6) = \#10 \end{bmatrix}$$

$$\begin{bmatrix} \text{SYN} & \zeta\,(\#1,\#3) = \#7 \\ \text{SEM} & \xi(\#2,\#4) = \#8 \end{bmatrix}$$

$$\begin{bmatrix} \text{SYN} & \#1 \\ \text{SEM} & \#2 \end{bmatrix}$$

$$\begin{bmatrix} \text{SYN} & \#1 \\ \text{SEM} & \#2 \\ \text{PHON} & \text{/diks/} \end{bmatrix} \quad \begin{bmatrix} \text{SYN} & \#3 \\ \text{SEM} & \#4 \\ \text{PHON} & \text{/era:/} \end{bmatrix} \quad \begin{bmatrix} \text{SYN} & \#5 \\ \text{SEM} & \#6 \\ \text{PHON} & \text{/mus/} \end{bmatrix}$$
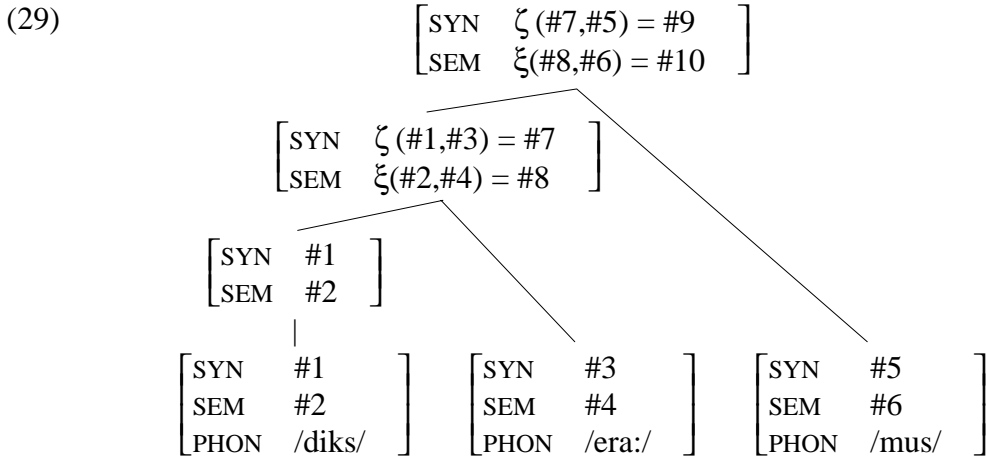
At this point, it is clear that the only terminal-based aspect of Lieber's approach is its treatment of phonology. Nonterminal nodes in Lieber's constituent structures bear syntactic and semantic information. The phonological form that is input to phonetic implementation needs to be determined by a phonological module applying to the phonological information supplied by the terminal nodes. The decision to single out phonology as the only type of information borne exclusively by terminal nodes (contrasting with syntactic and semantic information borne by nonterminal as well as terminal nodes) is arbitrary.[9]

An internally more consistent approach would treat phonological information on a par with syntactic and semantic information. In such an approach, nonterminal nodes would carry phonological as well as syntactic and semantic information. The phonological information of a nonterminal node would be subject to constraints relating it to the phonology of the immediate constituents. The resulting representation of the Latin verb form is shown in (30).

(30)
$$\begin{bmatrix} \text{SYN} & \zeta\,(\#10,\#7) = \#13 \\ \text{SEM} & \xi(\#11,\#8) = \#14 \\ \text{PHON} & \varphi(\#12,\#9) = \#15\text{/diksera:mus/} \end{bmatrix}$$

$$\begin{bmatrix} \text{SYN} & \zeta\,(\#1,\#4) = \#10 \\ \text{SEM} & \xi(\#2,\#5) = \#11 \\ \text{PHON} & \varphi(\#3,\#6) = \#12\text{/diksera:/} \end{bmatrix}$$

$$\begin{bmatrix} \text{SYN} & \#1 \\ \text{SEM} & \#2 \\ \text{PHON} & \#3\text{/diks/} \end{bmatrix}$$

$$\begin{bmatrix} \text{SYN} & \#1 \\ \text{SEM} & \#2 \\ \text{PHON} & \#3\text{/diks/} \end{bmatrix} \quad \begin{bmatrix} \text{SYN} & \#4 \\ \text{SEM} & \#5 \\ \text{PHON} & \#6\text{/era:/} \end{bmatrix} \quad \begin{bmatrix} \text{SYN} & \#7 \\ \text{SEM} & \#8 \\ \text{PHON} & \#9\text{/mus/} \end{bmatrix}$$

---

[9] This arbitrary decision costs Lieber's approach dearly: she is forced to assign nonconcatenative morphology to a separate "transformational" module, as terminal-based constituent structures are unable to deal with such phenomena.

This is of course identical to the sign-based representation in (30).[10] At this point, it should be clear that even approaches implicitly stated in terminal-based terms possess all the tools necessary to achieve a nonderivational account of interleaving effects. Criticisms of interleaving as "derivational" or "formally extraneous" (see (3)-(7)) appear to be based on a lack of understanding of the formal properties of a constituent structure.

5. Comparison of Sign-Based Morphology with paradigmatic approaches

Having showed that interleaving is (a) necessary, (b) a natural consequence of constituent structures and thus (c) nonderivational, I will now show that the theory of Sign-Based Morphology provides a superior account of the phonology-morphology interaction than can be found in the recent paradigmatic approach, represented by Steriade 1994, McCarthy 1994, Benua 1995, Kenstowicz 1995, and others, which holds that interleaving effects are only apparent. According to the advocates of the paradigmatic approach to the phonology-morphology interaction, interleaving effects result from paradigm uniformity requirements: morphologically related words must be phonologically similar. These effects hold only between words (i.e., "surface" or "output" forms).

I illustrate this approach by summarizing Kenstowicz's (1995) Optimality Theoretic analysis of Northern Italian s-voicing, based on data discussed by Nespor and Vogel 1986. In the relevant dialects, [s] and [z] are in complementary distribution, with [z] appearing intervocalically:

(31) azola   'button hole'
      azilo   'nursery school'
      kaz-a   'house'
      kaz-ina   'house-DIMINUTIVE'

As noted by Nespor and Vogel, s-voicing does not apply consistently across morpheme boundaries. The rule applies in (32a,c), but not in (32b):

(32) a.   diz-onesto   'dishonest'
            diz-uguale   'unequal'
      b.   a-sotʃale   'asocial'
            bi-sessuale   'bisexual'
            ri-suonare   'to ring again'
            pre-sentire   'to hear in advance'
      c.   re-zistenza   'resistance'
            pre-zentire   'to have a presentiment'

Kenstowicz claims, following Nespor and Vogel, that the failure of s-voicing to apply in (32b) is connected to the fact that the stem is an independent word in these forms. The contrast between *rezistenza* and *asotʃale* is to be explained by the fact that the stem is an independent word in the latter but not in the former.[11] In the paradigmatic approach, this idea is implemented by invoking correspondence constraints between related words. Thus, identity constraints are enforced between *sotʃale* and *asotʃale*. By ranking the identity constraints

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[10]   Bird 1990 presents the same kind of structure in his introduction to unification-based grammar formalisms. However, he does not recognize the implications of this for interleaving.

[11]   This difference between bound and free morphs was noted by Kiparsky 1982, who proposed to account for it by assuming that free morphs undergo a root cycle while bound morphs do not (see also Inkelas 1990). As I will show shortly, (§5.2) Kiparsky's approach (although stipulative) has greater empirical success than the paradigmatic approach. This is because morphologically complex stems are *always* cyclic domains, even when they are not possible words. See Orgun 1994c, 1995a for discussion of this issue from a Sign-Based Morphology perspective.

higher than the phonotactic constraint responsible for s-voicing, the failure of voicing to apply to *asotfale* can be accounted for. In the case of *dizonesto*, *dis* is not an independent word. Therefore, no paradigmatic correspondence constraints apply. There is nothing to block s-voicing.[12]

In this section, I will present challenges to this kind of approach and demonstrate that Sign-Based Morphology deals successfully with these challenges.

Arguments against the paradigmatic approach come from four general sources: (1) the "inside-out" nature of interleaving effects, (2) the fact that morphological constituents which are not possible words can nonetheless function as cyclic domains, (3) the need to contrast cyclic and noncyclic phonology, and (4) underspecification effects (in which material in a daughter constituent is underspecified; thus the daughter is not a possible word). I will discuss the first three of these in detail in the following sections, illustrating how Sign-Based Morphology copes successfully with the appropriate data.[13]

5.1 Inside-out nature of interleaving effects

Inside-out effects are those in which a morphologically simpler constituent affects the form of a morphologically more complex constituent of which it is a part, but not vice versa. This section illustrates the inside-out nature of interleaving on the basis of Turkish data. The phenomenon in question is a disyllabic size condition, which certain speakers of Turkish impose on suffixed forms (Itô and Hankamer 1989, Orgun and Inkelas 1992, Inkelas and Orgun 1995a).

(33)   Suffixed words must contain at least two syllables.

sol^j	'musical note "sol"'	do:	'musical note "do"'
sol^j-ym	'my "sol"'	*do:-m	Intended: 'my "do"'
sol^j-ym-y	'my "sol"-ACC'	*do:-m-u	Intended: 'my "do"-ACC'
sol^j-y	'"sol"-ACC'	do:-ju	'"do"-ACC'

The data in (33) show that monosyllabic roots may surface as words on their own. However, suffixed forms must contain two syllables. The form *do:-m-u 'my "do"-ACC' is ungrammatical even though it contains two syllables by virtue of the extra accusative suffix it carries. Our main task is to account for the ungrammaticality of this form.

The paradigmatic approach would have to deal with this problem as follows: The form *do:-m-u 'my "do"-ACC' is ungrammatical because the morphologically related form *do:-m 'my "do"' is ungrammatical. Paradigm uniformity results in uniform ungrammaticality.
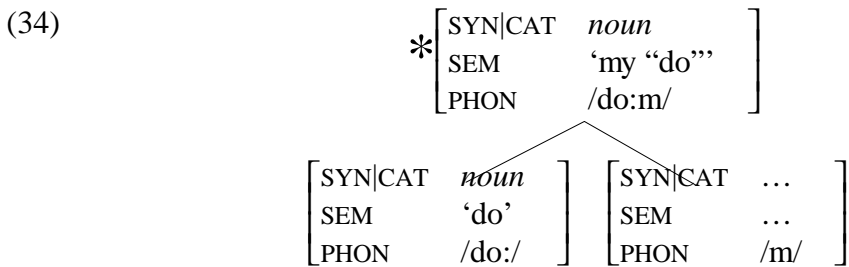
This account sounds fine until we confront the following question, so simple that one runs the risk of overlooking it: The ungrammaticality of the morphologically complex form *do:-m 'my "do"' does not make the root *do* ungrammatical. Why?

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[12]   This account cannot, however, handle the contrast between *presentire* and *prezentire*, which both involve the same stem *sentire*, which occurs independently as a word on its own. In Lexical Phonology terms, this contrast is accounted by invoking a pre-affixal stem cycle in one case but not the other. See Inkelas 1990 for details of this idea. In Sign-Based Morphology, this can be handled by enforcing phonological constraints on the daughter node of constructions. See Stump 1995 and Orgun 1995d for discussion of this possibility.

[13]   The paradigmatic interpretation of sign-based structures suggested in §4 does not suffer from this defects: essentially, this interpretation states that interleaving effects result from correspondences between lexical entries which may or may not be words. However, this interpretation runs into problems with lexical entries whose morphosyntactic realization may consist of several noncontiguous elements (see Ackerman and LeSourd 1993, Ackerman 1995, Goldberg 1996; another good case is found in Inkelas 1993b, though she does not discuss it in these terms). The structural interpretation of sign based linguistics deals with such cases with no difficulty.

What we are seeing here is that the ungrammaticality of one form results only in the ungrammaticality of *more complex* related forms, not *less complex* related forms within the same paradigm. The immunity of the morphologically simpler form from paradigm uniformity effects follows from nothing in the theory. It must be stipulated (as "primacy of the base"[14] in Benua 1995 and McCarthy 1995). That is, the paradigmatic approach must *stipulate* the most basic property of interleaving effects, namely their inside-out nature.
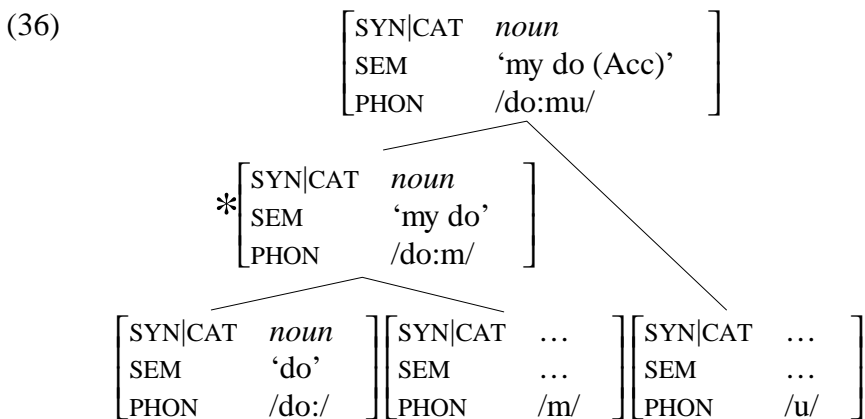
No stipulation needs to be made in Sign-Based Morphology. Inside-out effects are a result of the basic architecture of the theory. Example (34) illustrates the structure of the ungrammatical form *do:-m* 'my "do"'. This form is ungrammatical because the phonological string of the top node violates the disyllabic minimal size condition, which applies to all branching nodes.

(34)

$$
\ast \begin{bmatrix} \text{SYN|CAT} & \textit{noun} \\ \text{SEM} & \text{'my "do"'} \\ \text{PHON} & \text{/do:m/} \end{bmatrix}
$$

$$
\begin{bmatrix} \text{SYN|CAT} & \textit{noun} \\ \text{SEM} & \text{'do'} \\ \text{PHON} & \text{/do:/} \end{bmatrix} \quad \begin{bmatrix} \text{SYN|CAT} & \ldots \\ \text{SEM} & \ldots \\ \text{PHON} & \text{/m/} \end{bmatrix}
$$

Example (35) shows the structure of the grammatical form *do:-ju* 'do-ACC'. This form is grammatical because every node in the constituent structure satisfies all relevant grammatical requirements. In particular, there is no node that violates the disyllabic minimal size condition.

(35)

$$
\begin{bmatrix} \text{SYN|CAT} & \textit{noun} \\ \text{SEM} & \text{'do (ACC)'} \\ \text{PHON} & \text{/do:ju/} \end{bmatrix}
$$

$$
\begin{bmatrix} \text{SYN|CAT} & \textit{noun} \\ \text{SEM} & \text{'do'} \\ \text{PHON} & \text{/do:/} \end{bmatrix} \quad \begin{bmatrix} \text{SYN|CAT} & \ldots \\ \text{SEM} & \ldots \\ \text{PHON} & \text{/u/} \end{bmatrix}
$$
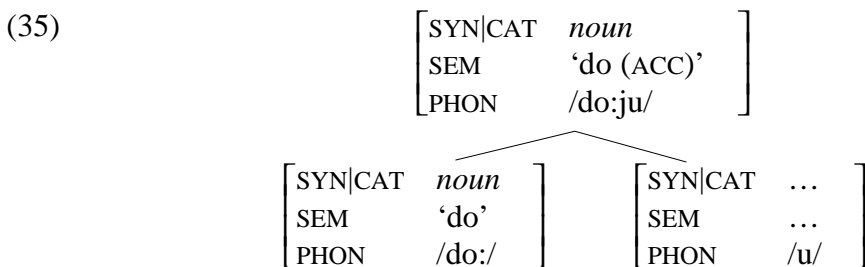
Example (36) illustrates the crucial form **do:-m-u* 'my "do"-ACC', which is ungrammatical even though it contains two syllables. This form is ungrammatical because not every node in the constituent structure satisfies every relevant grammatical requirement. In particular, the intermediate node **do:-m* 'my "do"' violates the disyllabic minimal size requirement.

(36)

$$
\begin{bmatrix} \text{SYN|CAT} & \textit{noun} \\ \text{SEM} & \text{'my do (Acc)'} \\ \text{PHON} & \text{/do:mu/} \end{bmatrix}
$$

$$
\ast \begin{bmatrix} \text{SYN|CAT} & \textit{noun} \\ \text{SEM} & \text{'my do'} \\ \text{PHON} & \text{/do:m/} \end{bmatrix}
$$

$$
\begin{bmatrix} \text{SYN|CAT} & \textit{noun} \\ \text{SEM} & \text{'do'} \\ \text{PHON} & \text{/do:/} \end{bmatrix} \begin{bmatrix} \text{SYN|CAT} & \ldots \\ \text{SEM} & \ldots \\ \text{PHON} & \text{/m/} \end{bmatrix} \begin{bmatrix} \text{SYN|CAT} & \ldots \\ \text{SEM} & \ldots \\ \text{PHON} & \text{/u/} \end{bmatrix}
$$

---

[14]   The need to invoke the notion of "base" is by itself sufficient to show that the relations being dealt with are syntagmatic rather than paradigmatic.

Finally, (37) shows the structure of the form *do* 'do'. This is the form whose grammaticality does not receive a satisfactory account in the paradigmatic approach. From a Sign-Based Morphology perspective, it is clear why this form is grammatical. There is no node that violates any grammatical condition. Note that there is no way a related morphologically more complex form could have an effect on this word. This is because more complex forms, even if morphologically related, are not part of the representation of the simplex form *do*.

(37)
$$\begin{bmatrix} \text{SYN|CAT} & noun \\ \text{SEM} & \text{'do'} \\ \text{PHON} & \text{/do:/} \end{bmatrix}$$

The same problem is present in Kenstowicz's analysis of Italian s-voicing I have already discussed in section 5. The main point of that analysis was that intervocalic s-voicing fails to apply in *asotʃale* because of identity constraints holding between this form and the related word *sotʃale*. The pair *<sotʃale, asotʃale>* satisfies identity better than the pair *<sotʃale, *azotʃale>*. However, it is also necessary to account for the fact that the pair *<*zotʃale, azotʃale>*, which satisfies identity just as well, is not attested. In general, why is it that morphologically simpler forms do not accommodate to constraints imposed on related more complex forms? A principled account of such inside-out effects is not possible within the paradigmatic approach. Proponents of this approach are forced into the unmotivated and arbitrary stipulation of "the primacy of the base" just in order to encode this basic property of interleaving effects.

In summary, the inside-out nature of interleaving effects is an automatic consequence of stating that some forms are morphologically simple, and morphologically complex forms may be derived from (or related to) them in Sign-Based Morphology. Paradigmatic approaches must stipulate this.[15]

5.2 Bound stems

According to the paradigmatic approach, interlexical correspondences apply only between words. The paradigmatic approach is thus unable to account for those cases in which morphologically complex stems function as cyclic domains, even if they are bound (i.e., not possible words on their own). The Bantu family is rife with such examples; as is well known, the Bantu verb stem is the domain for many phonological and morphological operations despite being unable to occur as a word without obligatory inflectional affixes. I will consider one example from Bantu here, a case from Cibemba in which a particular phonological alternation has to apply cyclically within the verb stem to constituents which are not words.

In Cibemba (the data are from Hyman 1994), the superclosed vowel [i̧], occurring in certain suffixes, triggers mutation of the preceding (nonnasal) consonant. As shown in (38), labial consonants mutate to [f], while coronal and dorsal consonants mutate to [s]. (See Zoll 1994 for an analysis of mutation within Optimality Theory (Prince and Smolensky 1993).)

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[15] Inasmuch as this stipulation is equivalent to stipulating that the morphologically complex form is derived from the simpler form, the Benua-McCarthy approach can, ironically, be argued to be just as derivational as the original Lexical Phonology conception of cyclicity that it is meant to replace.

(38)   Mutation

Verb root		Causative	
-leep-	'be long'	-leef-į-	'lengthen'
-up-	'marry'	-uf-į-	'marry off'
-lub-	'be lost'	-luf-į-	'lose'
-lob-	'be extinct'	-lof-į-	'exterminate'
-fiit-	'be dark'	-fiis-į	'darken'
-ónd-	'be slim'	-óns-į-	'make slim'
-buuk-	'get up'	-buus-į-	'get (someone) up'
-lúng-	'hunt'	-lúns-į-	'make hunt'

The crucial evidence for interleaving comes from the overapplication of mutation in causative applicative forms where, as shown in (39), the final consonant of the root unexpectedly mutates along with the final consonant of the applicative:

(39)   The crucial evidence for interleaving: Double mutation.

Applicative		Applicative-causative
-leep-el-	'be long for~at'	-leef-es-į-
-up-il-	'marry for~at'	-uf-is-į-
-lub-il-	'be lost for~at'	-luf-is-į-
-lob-el-	'be extinct for~at'	-lof-es-į-
-fiit-il-	'be dark for~at'	-fiis-is-į-
-ónd-el-	'be slim for~at'	-óns-es-į-
-lil-il-	'cry for~at'	-lis-is-į-
-buuk-il-	'get up for~at'	-buus-is-į-
-lúng-il-	'hunt for~at'	-lúns-is-į-

One possible account of these data might be that mutation is iterative, characterized by unbounded leftward spreading of some feature from the superclosed vowel [į]. As Hyman (1994) shows, however, this analysis will not work. Hyman cites examples such as those in (40) which make it clear that mutation does not apply iteratively within roots.

(40) No root internal mutation

a)	-kálip-	'be painful'	-kálif-į-	'cause pain'
			*-sásif-į-	
b)	-polopook-	'crackle'	-polopoos-į-	'make crackle'
			*-fosofoos-į-	
c)	-pemekees-	'pant'	-pemekees-į-	'make pant'
			*-pemesees-į-	

As Hyman shows, mutation does not apply iteratively across the intransitive reversive affix -*uk* either:

(41) No double mutation across Intransitive reversive -*uk*

Verb	Intransitive reversive	Intransitive reversive - causative	
-kak-	-kak-uk-	-kak-us-į-	'tie'
		*-kas-us-į-	
-ang-	-ang-uk-	-ang-us-į-	'feel light'
		*-ans-us-į-	
-sup-	-sup-uk-	-sup-us-į-	'be lively'
		*-suf-us-į-	

Only the final [k] of the intransitive reversive suffix—not the root consonant preceding it—is subject to mutation. What, then, is the difference between the applicative affix and the intransitive reversive?

Hyman (1994) proposes an analysis of double mutation in Cibemba using Hammond's (1991) mechanism of morphemic circumscription. According to this analysis, the causative suffix -į is added to the verb root first. Mutation applies on this cycle. Next, on the applicative cycle, the causative morph is identified and detached by morphemic circumscription so that the applicative may attach to the bare root. The causative affix is reattached and mutation applies again. This analysis is summarized in (42).

(42)   'lengthen for'

UR	Root	leep
1st cycle	Affixation	[[leep] į]
	Mutation	leefį-
2nd cycle	Affixation	[[leefį] il]
	Morphemic circumscription	[[leef] il] <į>
	Mutation	leefesį-

This is obviously a derivational analysis. Can the data be handled in a nonderivational manner?
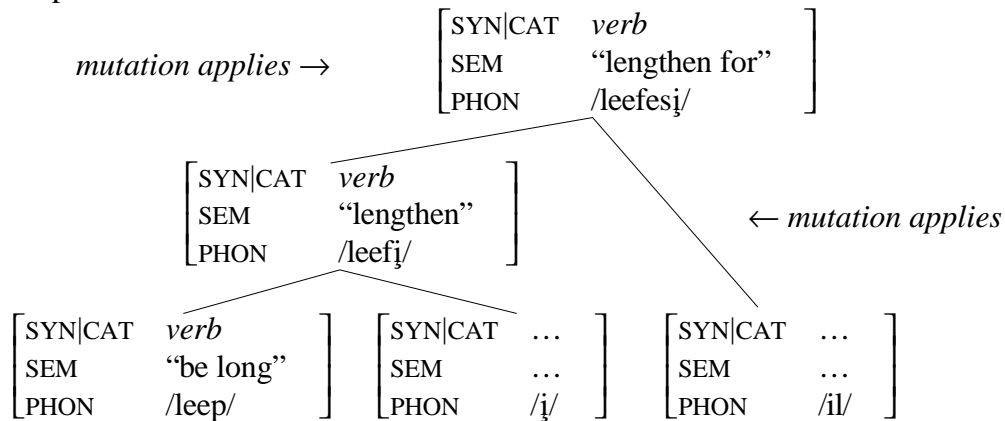
The first step in developing such an analysis is to notice that in order to carry out morphemic circumscription, the phonology needs to perform two tasks. The first is to determine that the base of affixation contains a particular morpheme (in this case, the causative suffix -į). This is necessary because the applicative morpheme -il- will attach as a simple suffix to bases not containing this morpheme. The second task is to identify the part of the phonological string that belongs to the causative morpheme, so that the applicative -il may be placed before it (i.e., attached as a suffix to the remainder of the base):

(43)   Tasks required to carry out morphemic circumscription:
         a)   Determine that the base contains a specific morpheme.
         b)   Identify the part of the base that belongs to that morpheme.

A simpler analysis immediately suggests itself (Orgun 1995a). Once task (43a) has been carried out (i.e., once we know that we have a causative verb stem), the applicative can be treated as a simple phonological infix. There is no need to perform task (43b), i.e. to identify *where* the causative morph lies in the stem. As McCarthy and Prince 1994, 1995 have shown, the placement of infixes is determined by optimal syllable structure concerns. An infix of the shape VC will necessarily attach inside the final V of a V final stem, for this is the location that minimizes the number of undesirable open syllables. In Hyman's analysis, it is a coincidence that interfixation gives rise to the best possible syllable structure. Since this is exactly what an infix is expected to do on universal grounds, the infixation analysis is preferable.

As an extra bonus, the infixation analysis is consistent with Sign-Based Morphology— and is nonderivational. This point is illustrated in (44), which shows the full sign-based structure of the form [leefesį] 'lengthen for'.

(44) Example

$$\begin{bmatrix} \text{SYN|CAT} & verb \\ \text{SEM} & \text{"lengthen for"} \\ \text{PHON} & \text{/leefesį/} \end{bmatrix}$$

mutation applies →

$$\begin{bmatrix} \text{SYN|CAT} & verb \\ \text{SEM} & \text{"lengthen"} \\ \text{PHON} & \text{/leefį/} \end{bmatrix}$$

← *mutation applies*

$$\begin{bmatrix} \text{SYN|CAT} & verb \\ \text{SEM} & \text{"be long"} \\ \text{PHON} & \text{/leep/} \end{bmatrix} \quad \begin{bmatrix} \text{SYN|CAT} & \dots \\ \text{SEM} & \dots \\ \text{PHON} & \text{/į/} \end{bmatrix} \quad \begin{bmatrix} \text{SYN|CAT} & \dots \\ \text{SEM} & \dots \\ \text{PHON} & \text{/il/} \end{bmatrix}$$

In summary, whether one takes a derivational (Hyman 1994) or a nonderivational (Orgun 1995a) approach to Cibemba double mutation, it is clear that consonant mutation must identify stems like *leefį* 'lengthen' as cyclic domains. Yet *leefį* is not a possible word. Verb stems in Bantu are not, in general, possible words, as they are devoid of inflectional material that all verbs must possess. Data of this kind show that the contention of Benua 1995, Flemming 1995, Kenstowicz 1995, and McCarthy 1995 (see also Booij 1995) that cyclic domains must be words is untenable. Lexical entries may function as cyclic phonological domains even if they are not actual or possible words. This is of course exactly as predicted by Sign-Based Morphology: every node in a given constituent structure is subject to phonological constraints, whether or not it corresponds to an independent word.[16]

5.3 Cyclic versus noncyclic effects

The appeal of the paradigmatic approach, once one sets aside the problems noted above, lies in its ability to deal with interleaving effects. Correspondences between related words give rise to apparently cyclic phonological effects. However, the paradigmatic approach has no way to deal with *noncyclic* effects, the subject of the present section.

An excellent example of the contrast between cyclic and noncyclic phonology comes from the Turkish minimal size condition (Itô and Hankamer 1989, Orgun and Inkelas 1992, Inkelas and Orgun 1995a) that was introduced in section 5.1, where it was shown that a word whose total size is two syllables may nonetheless be ungrammatical because it has a subconstituent that violates the disyllabic minimal size condition. Example (45) shows that the passive suffix as well as the possessive suffix may give rise to minimality violations.

(45) a) monomorphemic forms   b) suffixed forms (min 2σ)

je	'eat!'	*je-n	'eat-pass'
do:	'musical note do'	*do:-m	'do-1SGPOSS'
jut	'swallow!'	jut-ul	'swallow-PASS'
solʲ	'musical note sol'	solʲ-ym	'sol-1SGPOSS'

---

[16] Note that the insistence on word-based correspondences leads the paradigmatic approach to make an absurd prediction. Consider a language with obligatory inflectional morphology (e.g., every noun must bear an overt case morpheme). In such a language, the word-based paradigmatic approach predicts no interleaving effects within derivational morphology, since derivational morphology does not create surface forms. Now, consider another language identical to the first one, except that there is no overt nominative morpheme. In this language, interleaving effects are predicted to occur in derivational nominal morphology, since such morphology creates possible surface forms, namely nominative nouns. Considerations like this have prompted Aronoff, once the staunchest proponent of word based morphology (Aronoff 1976), to abandon this position and defend what he now calls stem-based morphology (Aronoff 1994, see also Anderson 1992).

Although repair by adding more suffixes is not possible for possessive forms (46a), subminimal passive forms may be rendered grammatical by the addition of, for example, an aspect suffix, which brings the total size to two syllables (46b) (Orgun and Inkelas 1992, Inkelas and Orgun 1995a):

(46) a) repair not possible: b) repair possible
         *do:-m   'do-1SGPOSS'   *je-n   'eat-PASS'
         *do:-m-u   'do-1SGPOSS-ACC'   je-n-ir   'eat-PASS-IMPRF'
          solʲ-ym-y   'sol-1SGPOSS-ACC'   jɯka-n-ɯr   'wash-PASS-IMPRF'

The forms in (46a) make sense in a cyclic approach, as we have already seen in §5.1: the subconstituent N-POSS (here *do:-m 'my "do"') is subject to minimality, which it violates. The forms in (46b), however, call for a noncyclic approach: the whole word is grammatical if it is two syllables.

        As in Orgun 1994a, 1995b,c, I propose that the proper analysis of these forms requires allowing *n*-ary branching structures (where *n*>2). The form *je-n-ir* 'eat-PASSIVE-IMPRF' has a ternary branching (i.e. "flat") structure:

(47)
$$\begin{bmatrix} \text{SYN|CAT} & verb \\ \text{SEM} & \text{'is eaten'} \\ \text{PHON} & \text{/jenir/} \end{bmatrix}$$

$$\begin{bmatrix} \text{SYN|CAT} & verb \\ \text{SEM} & \text{'eat'} \\ \text{PHON} & \text{/je/} \end{bmatrix} \begin{bmatrix} \text{SYN|CAT} & \dots \\ \text{SEM} & \dots \\ \text{PHON} & \text{/n/} \end{bmatrix} \begin{bmatrix} \text{SYN|CAT} & \dots \\ \text{SEM} & \dots \\ \text{PHON} & \text{/ir/} \end{bmatrix}$$

The constituent structure in (47) makes it clear why the form *je-n-ir* 'is eaten' is grammatical: There is no node here that violates the disyllabic minimal size condition.

        The contrast between flat and branching structures, which allows Sign-Based Morphology to encode the difference between cyclic and noncyclic phonological effects, is not an ad-hoc stipulation. There is independent evidence for the branching structures needed for the apparent cyclic enforcement of the minimal size condition in nominal forms (Orgun 1994b, 1995b,c, Inkelas and Orgun 1995a). The evidence comes from Suspended Affixation, described by Lewis (1967: 35) as a construction in which "one grammatical ending serves two or more parallel words."

        An example is shown in (48a), where the nouns *sɯhhat* 'health' and *a:fijet* 'well being' are conjoined; the locative suffix, which has scope over both of them, is found only once at the end of the conjoined phrase. Example (48b) is similar. Further examples can be found in Lewis 1967, Underhill 1976, and Inkelas and Orgun 1995a.

(48) a) *sɯhhat ve a:fijet-te*   b) *halk-ɯn [adʒɯ ve sevintʃ-ler-i]*
          health and well-being-LOC   people-GEN sorrow and joy-PL-POSS
          'In health and well-being'   'the people's sorrows and joys'

Example (49) shows the null hypothesis for the structure of this construction. I assume that the constituent structure is as implied by the scope relations, with the locative suffix is attached to the whole conjoined NP.

(49)   [[*sɯhhat ve a:fijet*]   *te*]

There are initially puzzling restrictions on the combinations of affixes that Suspended Affixation can target. As seen in (50a), it is possible to suspend ALL eligible affixes. Here, the plural suffix *-ler*, the possessive *-im*, and the accusative suffix *-i* are all suspended. Example

(50b) shows that it is acceptable not to suspend any affixes at all. Here, all suffixes are realized on both conjuncts.

(50) a)   All affixes suspended: [*tebrik ve teʃekkyr*]-*ler-im-i*
                                     [congratulation & thank]-PL-1SGPOSS-ACC
                                     'my congratulations and thanks (acc)'

    b)   No affixes suspended: *tebrik-ler-im-i ve teʃekkyr-ler-im-i*

Example (51) shows the puzzling restrictions on Suspended Affixation. In (51a), we see that it is possible to suspend just the accusative suffix *-i* while realizing the plural and possessive suffixes on both conjuncts. Example (51b) shows that it is NOT possible to realize the plural suffix *-ler* on both conjuncts while suspending the possessive and accusative suffixes.

(51)   Suspension of some but not all affixes.
        a)   [*tebrik-ler-im ve teʃekkyr-ler-im*]-*i*
        b)   * [*tebrik-ler ve teʃekkyr-ler*]-*im-i*

Our task is to account for this inseparability of the plural and possessive suffixes in Suspended Affixation. That is, we need to find a formal account of the observation that the plural and possessive suffixes are either both realized on all conjuncts or both suspended.
        I offer an analysis of this seemingly strange restriction in terms of constituent structure. I claim that the plural and possessive suffixes form a flat (ternary branching) structure with the base they attach to, as in (52b), rather than a binary branching structure as in (52a).

(52)   a) *
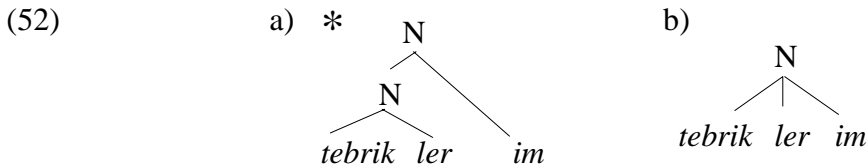
The plural and possessive suffixes have to be sisters whenever they are both present (52b). Given that the plural and possessive suffixes form a ternary branching structure with the base they attach to, the pattern of suspension in (53) is ungrammatical because it forces the plural and possessive suffixes to be in a hierarchical structure. This example is similar to the one we have seen before in (52b), except that the accusative suffix is not involved here. This further supports the position that the source of the problem is the configuration of the plural and possessive suffixes. There are two possible structures for this form. The first is shown in (53a). Here, the possessive suffix is attached to the conjoined NP, as it has scope over both conjuncts. This configuration violates the condition that the plural and possessive suffixes must be sisters whenever they both have scope over the same head. Therefore, this structure is ruled out. This leaves us with the possibility in (53b), which is structurally well formed. However, this structure does not give us the desired scope relations. In particular, the possessive suffix has scope over the second conjunct but not the first conjunct. Therefore, we explain the fact that the plural and possessive suffixes have to be suspended together, or not suspended at all.

(53)   *[*tebrik-ler ve teʃekkyr-ler*]-*im*
        [thank-PL & congratulation-PL]-1SGPOSS
        a)   b)

Problem: *-ler* and *-im* not sisters   Problem: Incorrect scope (*-im*)

In general, then, suffixes can be separated in Suspended Affixation only if they form a hierarchical structure. If they form a flat structure, they have to be suspended as a group, or not at all. See Orgun 1995b,c for more details.

Suspended Affixation data show that the possessive and accusative suffixes come in a hierarchical structure. Sign-Based Morphology predicts cyclic effects whenever hierarchical structures are found. Indeed, the minimal size condition exhibits cyclic effects in possessed accusative forms (*do:-m-u 'my "do"-ACC' is ungrammatical even though it contains two syllables, because the subconstituent *do:-m 'my "do"' is subminimal).

Thus, Sign-Based Morphology not only accounts for both cyclic and noncyclic phonology, but also relates the contrast to independently needed morphological structure. Past derivational approaches (e.g. Kiparsky 1982, Mohanan 1982, Halle and Vergnaud 1987, Halle and Kenstowicz 1991) have had to stipulate the difference between cyclic and noncyclic phonology, a distinction not motivated in any way by the morphology.

There are further difficulties that the paradigmatic approach faces that I will not discuss in detail here. The first difficulty is caused by underspecification of a subconstituent for some phonological structure. The most common case of this is final extrametricality. In these cases, the subconstituent in question is not a possible word. Inkelas and Orgun 1995a have used extrametricality in an analysis of Turkish plosive voicing alternations in a framework compatible with Sign-Based Morphology. Another challenge is posed by Sami data discussed in Dolbey 1996. As Dolbey shows, allomorph selection in Sami needs to make reference to a bound stem that is not a possible word on its own.

5.4 Real paradigmatic effects

In order to clinch the critique of the paradigmatic approach to interleaving effects, it may be fruitful to consider the range of paradigmatic effects found in diachronic data. We will see that such indubitably paradigmatic effects have quite different properties from interleaving effects. This confirms my contention that paradigm uniformity is not the right approach to deal with interleaving effects. In this short section, I will merely hint at the relevant phenomena, as diachronic linguistics is not the main focus of this paper.

Example (54) shows an example paradigm, consisting of the nominative, dative, locative, ablative, accusative, and genitive forms of the Uighur noun root *qazan* 'pot'. What makes this list of forms a paradigm is that they are all related to the same root *qazan* 'pot' by a family of morphological processes that realize different values of a given morphosyntactic feature (here CASE).

(54)   A paradigm:

root
qazan

	nominative	dative	locative	ablative	accusative	genitive
derived forms	qazan	qazanɣa	qazanda	qazandɨn	qazanni	qazannɨŋ
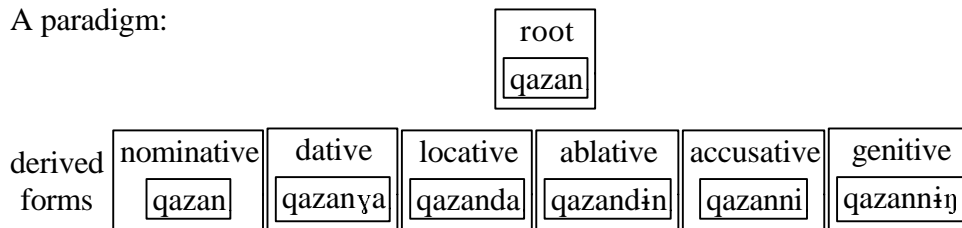
The following list summarizes the kinds of effects, synchronic and diachronic, that are found in paradigms of this sort.

- The root will have an effect on the derived forms. This is the only kind of effects observed in interleaving (the base of a paradigm need not be a root as in the example here, but may itself be morphologically complex). This is of course a syntagmatic and not a paradigmatic effect, since the derived forms are, by definition, derived from the root.
- One of the derived forms might affect the root. This kind of effect is called back-formation or reanalysis, depending on whether the root existed prior to this change or not. (See

Becker 1993 for discussion.) In synchronic interleaving effects, of course, derived forms never have an effect on the stems they are based on, a fact that forces Benua 1995 and McCarthy 1995 to stipulate the "primacy of the base." The lack of such primacy of the base effects in real (diachronic) paradigmatic phenomena is prima facie evidence that the paradigmatic approach to interleaving is fundamentally flawed.

- Any of the derived forms might affect the others. There is no guaranteed directionality to this kind of effect. This kind of effect is also commonplace diachronically, and is known as paradigm leveling. The existence and treatment of these effects has no bearing on the status of interleaving. As shown by Koenig and Jurafsky 1994, and Riehemann 1994, the formalism introduced in this talk can satisfactorily deal with this kind of effect.

While the second and third paradigmatic effects summarized above are common in diachronic processes, I argue that they differ in character from synchronic interleaving effects. It is therefore a mistake to invoke the same mechanism to deal with paradigmatic effects and interleaving effects.

6. Conclusions

The first conclusion of this study is that phonology-morphology interleaving is necessary if a principled account of certain types of phonology-morphology interaction is to be found.

The second conclusion is that there is nothing derivational about phonology-morphology interleaving. Thus, to take up the question that is the topic of this volume, is there then a derivational residue in phonology in this age of constraint based-theories? The answer depends solely on the nature of phonological theory. Past researchers (e.g. Lakoff 1993) have often failed to distinguish cyclic phonology from rule ordering within a cycle. The quest for a nonderivational theory of phonology, which should be limited in scope to eliminating rule ordering within a cycle, has erroneously been taken to entail endeavoring to eliminate cyclic phonology as well. As I have shown in this paper, any theory that utilizes constituent structures and feature percolation is able to derive interleaving effects from declarative constraints on static phrase structure configurations.

One question that must be answered is the following: Sign-Based Morphology is nonderivational, but is it empirically and theoretically superior to derivational approaches to interleaving (such as Lexical Phonology)? Is it superior to other nonderivational conceptions of the phonology-morphology interface? I contend that only Sign-Based Morphology has the virtue that cyclic and noncyclic effects follow from independently motivated morphological structure. Within past cyclic approaches, the cyclic-noncyclic distinction is stipulated. Current paradigmatic approaches have no way of addressing noncyclic effects at all.

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