Chapter 6. Remarks on the choice of phonological theory

In this chapter, I defend my choice of Optimality Theory as the theory of phonology to use in Sign-Based Morphology. I do this by presenting theoretical and empirical arguments against one-level phonology (Bird 1990, Scobbie 1991, Bird and Ellison 1994, Bird and Klein 1994), which is the only theory explicitly designed for use in unification-based grammar formalisms, which may therefore appear to be the obvious phonological theory of choice for Sign-Based Morphology as well.

Throughout this study, I have used Optimality Theory (Prince and Smolensky 1993) in my phonological analyses. This choice may seem unusual in the context of unification-based grammar, since, particularly in HPSG circles, it has often been taken for granted that the only way of doing phonology that is consistent with the spirit, if not the letter, of unification-based grammar is the one level approach proposed by Bird 1990, Scobbie 1991, Bird and Ellison 1994 and Bird and Klein 1994. I argue, on the contrary, that one-level phonology is not the inevitable choice of such frameworks, nor is it the optimal choice. Based on theoretical and empirical observations, I make the following claims:

i) Contra Bird et al., a two-level approach to the phonological function φ is well within the spirit of HPSG, in fact, more so than a one-level approach.

ii) The computational advantages of the one-level approach may be taken by some linguists as sufficient reason to adopt it, but

iii) The one level approach faces serious empirical difficulties because of its failure to distinguish between structure-filling and structure-changing phonological alternations.

iv) Bird and Ellison's (1994) arguments against rule-based approaches based on considerations of conspiracies (Kisseberth 1970) need not apply to all two-level approaches. There are surface-oriented two-level theories (such as the two-level version of Optimality Theory proposed by McCarthy and Prince 1994a,b, and used in the present study) that do not miss generalizations the way rule-based theories are claimed to.

I conclude that a two-level approach to the phonological function φ is a natural choice from a theoretical point of view, and is also empirically superior.

6.1 One level phonology

The leading idea in one-level phonology is that there is only one phonological description for any given linguistic form. The "surface" phonological string is one that simultaneously satisfies all constraints. Bird and Ellison (1994) make an analogy with syntax: in traditional transformational grammars, syntactic representations are manipulated by rules and changed into new representations. In most modern theories of syntax, most explicitly in unification-based theories such as HPSG, there is only one syntactic representation that

satisfies all constraints imposed on it. Thus, Bird and Ellison 1994 argue, phonology in a declarative, unification-based theory of grammar must be one-level as well.

In this section, I give a brief informal illustration of one-level phonology taken from Bird and Klein 1994, who assume the following feature geometry, adapted from Clements 1985. (The type *boolean* identifies a binary valued feature with possible values + and -. It is not clear how privative features are best modeled in this framework):

(346)
$$\begin{bmatrix} \textit{segment} & & \\ \text{LARYNGEAL} & \begin{bmatrix} \text{SPREAD} & \textit{boolean} \\ \text{CONSTRICTED} & \textit{boolean} \\ \text{VOICED} & \textit{boolean} \end{bmatrix} & \\ \text{SUPRALARYNGEAL} & \begin{bmatrix} \text{MANNER} & \begin{bmatrix} \text{NASAL} & \textit{boolean} \\ \text{CONTINUANT} & \textit{boolean} \\ \text{STRIDENT} & \textit{boolean} \end{bmatrix} \\ \text{PLACE} & \begin{bmatrix} \text{CORONAL} & \textit{boolean} \\ \text{ANTERIOR} & \textit{boolean} \\ \text{DISTRIBUTED} & \textit{boolean} \end{bmatrix} \end{bmatrix} & \end{bmatrix}$$

Bird and Klein 1994 make a fundamental contrast between objects and descriptions. Phonological representations are taken to be partial descriptions of phonetic events. Grammatical constraints are also partial descriptions of phonetic events. Each grammatical construction and lexical entry present in an utterance contributes to a pool of constraints on the object being described. A fully specified phonological representation results from the combination of constraints imposed by lexical entries and grammatical constructions. This fully specified representation is a maximally specific description of a phonetic event.

The phonological domain consists of descriptions. A partial description is satisfied by a class of objects. The more specific a description is, the smaller is the class of objects that satisfy it. Since phonological representations are descriptions, it is possible to use tools such as disjunction, negation, and implicational statements in grammatical constraints as well as lexical representations. Bird and Klein 1994 make full use of these tools. For example, suppose we want to add a statement of nasal place assimilation to our grammar. The following constraint (347) disallows nasals followed by stops of a different place of articulation (the symbol ¬ stands for negation):

(347)
$$\neg\, \textit{phrase} \left\langle \ldots \begin{bmatrix} \textit{segment} & \\ \text{SL} & \begin{bmatrix} \text{MANNER}|\text{NASAL} & + \\ \text{PLACE} & \boxed{1} \end{bmatrix} \end{bmatrix} \begin{bmatrix} \textit{segment} & \\ \text{SL} & \begin{bmatrix} \text{MANNER}|\text{CONT} & - \\ \text{PLACE} & \neg\boxed{1} \end{bmatrix} \end{bmatrix} \ldots \right\rangle$$

This constraint rules out a nasal segment followed by a stop whose place of articulation is not shared with the nasal. The additional assumption that lexical representations contain nasals unspecified for place completes the account of nasal place assimilation.

6.2 Cyclic effects in one-level phonology

Perhaps surprisingly, one-level phonology can deal quite elegantly with cyclic phonological effects (Cole and Coleman 1993). The main restriction imposed on phonology by Bird and Klein is that no deletion or structure-changing (delinking) is allowed. The issue of cyclic versus noncyclic phonological effects is largely independent of whether the alternations involved are structure-filling or structure-changing. Even though I have formulated a number of alternations as structure-changing in this study, most of those analyses can be restated in one-level terms by using disjunctions in lexical representations to avoid structure-changing alternations. It is therefore not necessarily the case that an approach to phonology that adopts Bird and Klein's principle of compositionality must necessarily be one-level or terminal-based (that is, committed to the absence of cyclic effects).

To see how cyclic effects can be handled in one-level phonology, consider the following representation of the English third person plural agreement suffix adopted from Bird and Klein 1994:

(348)
$$\begin{bmatrix} \textit{3ps} \\ \text{PHON} \quad \varphi(\boxed{1}, \boxed{2}) \\ \text{MORPH} \begin{bmatrix} \text{STEM} \begin{bmatrix} \textit{verb stem} \\ \text{PHON} \quad \boxed{1} \end{bmatrix} \\ \text{AFFIX} \begin{bmatrix} \textit{suffix} \\ \text{PHON} \ \boxed{2} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

This representation is equivalent to the Sign-Based Morphology representations in the earlier chapters of this work where affixes were represented as constituents. Just like in Sign-Based Morphology, Bird and Klein 1994 represent affixes as constructions, or, as they call them (following Riehemann 1994), as partially specified stems.

Bird and Klein 1994 impose the following constraint on the phonological function φ:

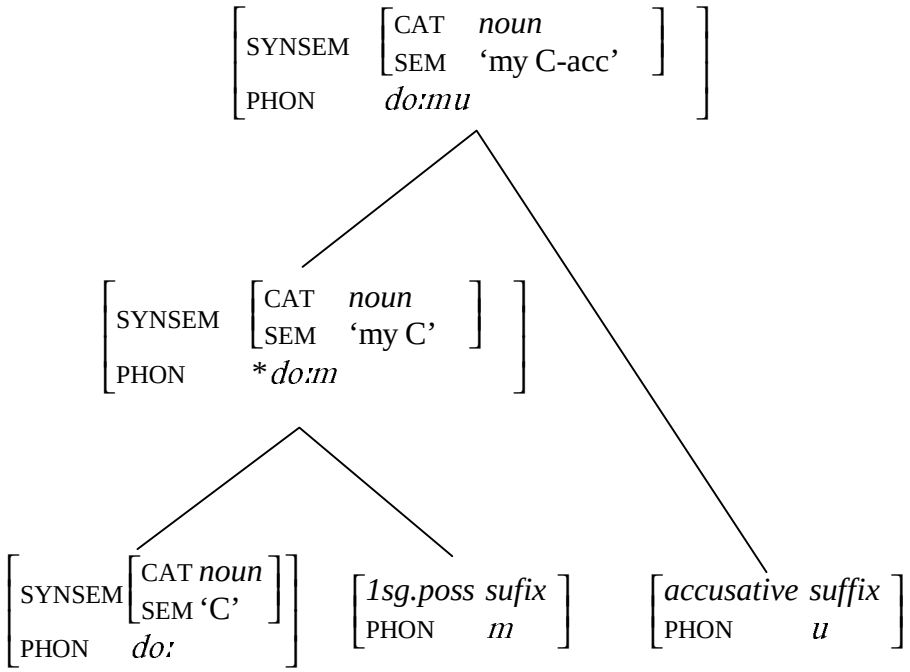
(349) Phonological compositionality: The phonology of a complex form can only be produced by either unifying or concatenating the phonologies of its parts.[63]

This principle of phonological compositionality in effect rules out all structure-changing phonology: it requires every piece of phonological information present in a daughter node to also be present in the mother node. According to the principle of compositionality, there cannot be any phonological deletion, deletion, or change in feature values.

63 The difference between unification and concatenation is subtle, and not important to our purposes here. Essentially, unification refers to combining partial descriptions of a single string into a more specific description. Concatenation involves the usual operation of adding two strings together to form a longer string.

Since cyclic phonological effects do not necessarily occur with structure-changing alternations, but may be found in structure-filling alternations as well, it is not surprising that Bird and Klein 1994's approach to phonology can handle them. For example, my treatment of the Turkish disyllabic minimal size condition in section 2.1 uses only structure-filling phonology (that is, no deletion of phonological material is used), and is therefore fully compatible with one-level phonology. To illustrate this point, I repeat the constituent structure for the ungrammatical form **do:-m-u* 'my C-acc' here. This form is ungrammatical because the subconstituent **do:-m* 'my C' violates the disyllabic minimal size condition, even though the whole word contains the requisite two syllables:

(350)



Notice that in this example the mother node phonology is always the concatenation of the daughter node phonologies. The analysis is therefore compatible with Bird and Klein Principle of Compositionality.

The status of structure-changing phonological alternations is more interesting. This problem is independent of cyclic effects. Therefore, I discuss it in a separate section.

6.3 Structure-changing alternations

Consider first a structure-filling phonological alternation, defined as one that can be modeled by underspecification. Turkish vowel harmony is such a case (Clements and Sezer 1982). For simplicity, I will only discuss front/back harmony, though the language also has rounding harmony. I will ignore disharmonic forms (e.g., *anne* 'mother', *inan* 'believe') for now, since it is necessary to use defaults, a mechanism we have not

discussed yet, to handle such forms. The issue of defaults will come up again in section 6.4.2.[64]

Disharmonic forms aside, the generalization is that only the first vowel in a word is distinctively specified for frontness. All others agree with the first one (351):

(351) ev-l^{j}er-in-de 'house-pl-poss-loc'
ɑt-lɑr-ɯn-dɑ 'horse-pl-poss-loc'

This alternation can be handled in one-level phonology by making a few assumptions. First, we assume that the initial vowel of each root is specified as front or back. Second, we assume all noninitial root vowels as well as all suffix vowels are unspecified for frontness. Finally, we make the following constraint part of the grammar (352):

(352)
$$\neg_{word} \left\langle \cdots \begin{bmatrix} vowel \\ \text{FRONT } \boxed{1} \end{bmatrix} \ consonant^{*} \ \begin{bmatrix} vowel \\ \text{FRONT } \neg\boxed{1} \end{bmatrix} \cdots \right\rangle$$

This constraint rules out consecutive vowels (with possible intervening consonants) that do not agree in frontness.

This analysis, which follows Clements and Sezer in spirit, is structure-filling, as we have assumed that noninitial vowels are lexically underspecified. Thus, the lexical representation for the word *evl^{j}erinde* is as shown in (353), where all suffix vowels are unspecified for frontness (following the tradition in Turkic linguistics, capital letters are used to indicate vowels that are specified for every relevant feature except, crucially, for frontness).[65]

(353) ev-l^{j}Er-In-dE

This lexical representation can successfully unify with the harmony constraint in (352), which requires all consecutive vowels to agree in frontness. The resulting fully specified representation has all front vowels (354):

(354) evl^{j}erinde

Let us turn to structure-*changing* phonological alternations. These pose a more interesting challenge to the Principle of Compositionality, since the apparent lexical representations do not unify with the observed surface ones. Lexical underspecification is not generally an option, as it would incorrectly neutralize needed contrasts. By way of illustration, consider the neutralization of all syllable codas to [h] in Slave (Rice 1989):

64 Defaults are used in some versions of Construction Grammar (Lakoff 1987, Goldberg 1992).
65 The [l] in the second morpheme in this form is assumed to be unspecified for palatality.

(355)	noun	my *noun*	gloss
	seh	se-zég-é	‘saliva’
	xéːh	se-ɣéːl-é	‘pack’
	xɑh	se-ɣɑl-é	‘club’
	sɑh	se-zɑh-é	‘bear’
	ɬeh	se-léh-é	‘coal’
	ʃih	se-ʒih-é	‘rock’
	ɬuh	se-lur-é	‘scab’
	ʃih	se-ʒíð-é	‘mountain’
	xoh	se-ɣoz-é	‘thorn’
	xeníh	se-ɣeníh-é	‘raft’
	ɬuh	se-luz-é	‘spoon’

The following consonants are seen to neutralize to [h] in (355): [g, l, r, ð, z].[66] Underspecification of lexical entries clearly is not enough to handle this alternation in a structure-filling manner (that is, without any deletion) as required by Bird and Klein’s Principle of Compositionality. How can one-level phonology then deal with this phenomenon?

Recall that the phonological domain consists of descriptions rather than objects, and that logical operations such as disjunction are available. The solution is, thus, to use disjunctions to handle apparently structure-changing alternations (Bird and Ellison 1994, Bird and Klein 1994). In the Slave case, we need to assume that all root-final consonants are specified by a disjunction between [h] and another consonant in the Slave inventory (356):[67]

(356)
$$\begin{bmatrix} \text{SYNSEM} & \begin{bmatrix} \text{CAT} & \textit{noun} \\ \text{SEM} & \text{‘spoon’} \end{bmatrix} \\ \text{PHON} & \{l, ɬ\}\, u\, \{h, z\} \end{bmatrix}$$

Next, we introduce a constraint that requires all codas to be [h]. Further, in order to prevent neutralization from applying to these consonants when they are in onset position, we need a constraint that prohibits [h] from occurring in that position. The problem with this move is that there are morphemes that have a nonalternating [h] that surfaces as such even in onset position. How can we prevent such forms from being judged ungrammatical?

The only solution to this problem is to invoke defaults, thus making the onset constraint applicable only to the disjunctively specified segments. Using the slash notation for defaults, we can state the onset constraint as follows:

66 I have not found examples with other consonants.

67 In (356), the curly brace notation is used to express disjunction, as in SPE.

(357) ONSET ⇒ /¬h

Given a lexical specification like {h,z}, this constraint will force the alternant that is not [h] to occur.

(358) Lexical representation: {l,ɬ}u{h,z}-é
Constraint: ONSET ⇒ /¬h

Result: luzé 'spoon-poss' (constraint satisfied)

When the lexical specification is [h], the constraint will have to be overridden.

(359) Lexical representation: {ʃ,ʒ}ih-é
Constraint: ONSET ⇒ /¬h

Result: ʒihé 'song-poss' (constraint overridden)

We have seen that it is necessary to use defaults to deal with some structure-changing alternations. This is slightly misleading in that defaults prove to be necessary to deal with certain alternations that are structure-filling as well.[68] Disharmonic forms in Turkish can be handled in a similar fashion by formulating the harmony constraint as a default one.

(360) Turkish vowel harmony (revised):

$$/\ \neg_{word} \langle \ \ldots \begin{bmatrix} vowel \\ \text{FRONT } \boxed{1} \end{bmatrix} \ consonant^* \ \begin{bmatrix} vowel \\ \text{FRONT } \neg\boxed{1} \end{bmatrix} \ldots \ \rangle$$

Harmonic morphemes can, and therefore must, satisfy this constraint:

(361) Lexical representation: ɑt-{l,lʲ}{ɑ,e}r

Result: ɑtlɑr 'horses' (constraint satisfied)

Disharmonic morphemes have fully specified vowels (rather than disjunctions between front and back vowels). Therefore they cannot satisfy the constraint, which is therefore overridden:

68 That is, alternations that can successfully be handled by underspecifying a feature value without recourse to other types of disjunction.

(362) Lexical representation: ɑt-kʲen

Result: ɑtkʲen ‘horse-adv’ (constraint overridden)

The tools necessary to deal with structure-changing alternations are disjunctions and defaults. While this can still be considered one-level phonology, it must be noted that it is not monotonic,[69] since it utilizes defaults and overrides (this is a more serious matter than using defaults in the type hierarchy, since defaults in the phonological mapping will give rise to nonmonotonicity in the on-line computation of actual forms, and will effectively cancel the computational advantages that form the strongest original motivation for one-level phonology).[70]

6.4 Critique of one-level phonology

6.4.1 The spirit of unification-based theories

Bird and Ellison 1994, Bird and Klein 1994 claim that their principle of phonological compositionality is required by the spirit of a constraint-based approach. They do acknowledge that the HPSG formalism (nor any other unification-based phrase structure formalism) does not impose any constraints on the kinds of phonological relations between a daughter node and a mother node, and therefore structure-changing phonology is allowed by the letter of unification-based formalisms. Indeed, Krieger et al. 1993 take an approach to phonology that does not assume the principle of compositionality, and is very similar to the one I adopt in this work. Krieger et al. 1993 analyze the alternations in the German second person singular suffix (363) using Finite State Transducers (Hopcroft and Ullman 1979, Koskenniemi 1983).

(363) sɑg-st ‘say’
ɑʁbɑɪt-əst ‘work’
mɪks-t ‘mix’

69 Part of the definition of monotonicity is that all constraints are surface-true. That is, no loss of information is allowed. While the extension of one-level phonology I have described in this section manages to avoid outright deletion, there is nonetheless inherent loss of information in overriding a constraint. The system is therefore nonmonotonic, and thus loses much of its formal and computational appeal.

70 Furthermore, note that using defaults and overrides amounts to admitting that it is after all acceptable to use Optimality Theory as the theory of phonology, since Optimality Theory is a theory of constraint conflict resolution, which may simply be viewed as defaults (lower ranking constraints) being overridden by higher-ranking constraints.

The relation between the daughter and mother node phonologies can be directly incorporated into the construction, as shown for *ɑʁbɑɪt-əst* (364) and *mɪks-t* (365) (the symbol ⁀ indicates concatenation):[71]

(364)
$$\begin{bmatrix} \text{PHON} & \boxed{1}\frown ə \frown \boxed{2} \\ \text{MORPH} & \begin{bmatrix} \text{STEM} & \boxed{1}\langle \ldots \{t, d\}\rangle \\ \text{SUFFIX} & \boxed{2}\langle st\rangle \end{bmatrix} \end{bmatrix}$$

(365)
$$\begin{bmatrix} \text{PHON} & \boxed{1}\frown\boxed{2} \\ \text{MORPH} & \begin{bmatrix} \text{STEM} & \boxed{1}\langle \ldots \{s, z\}\rangle \\ \text{SUFFIX} & \langle s\rangle \frown \boxed{2}\langle t\rangle \end{bmatrix} \end{bmatrix}$$

Examples (364) and (365) show that both the insertion of [ə] and the deletion of [s] can be handled quite straightforwardly within the HPSG formalism. However, Bird and Klein 1994 state that structures like those in (364) and (365) should be eschewed because they violate the Principle of Phonological Compositionality, which ensures that information-combining operations at the phonological level (that is, mechanisms that related daughter node phonologies to mother node phonologies) are monotonic,[72] in the sense that all information in the daughters is present also in the mother. They hold that this restriction is required by the spirit of a constraint-based formalism. The constructions in (364) and (365) utilize insertion (of [ə) and deletion (of [s]). They are therefore incompatible with the principle of compositionality.

Although Bird and Klein argue that constructions such as those in (364) and (365) should be disallowed because they violate the principle of compositionality, my contention is that the principle of phonological compositionality is not required by the "spirit of unification-based frameworks". On the contrary, the foundation of unification-based grammatical theories is that such a principle does not in general apply to phrase structures. To elucidate this point, consider the following figure, adopted from Bird 1990, that is intended to illustrate the basic architecture of a unification-based model of linguistics:

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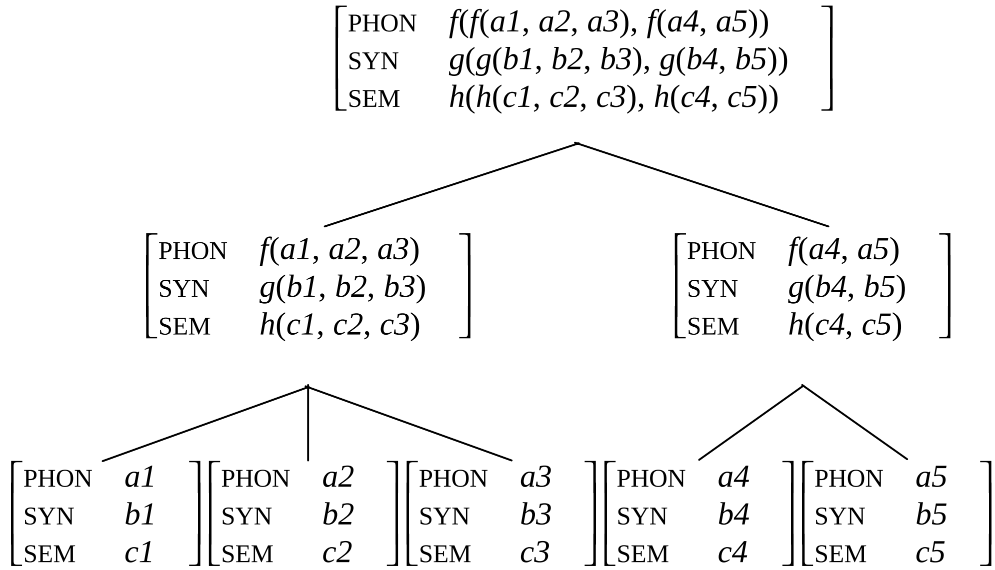
71 Attribute value representations of Finite State Transducers (à la Krieger et al.) tend to be very clumsy. It is therefore customary to employ a direct representation of the alternation in visual presentations, as I do here.

72 For our purposes, we may assume this to mean that:

i) there is no deletion of phonological material supplied by lexical forms, and
ii) all grammatical constraints are obeyed.

(366)



Notice that the syntactic and semantic functions *g* and *h* are not subject to anything like Bird and Klein 1994's principle of compositionality. There is no general condition in HPSG or any unification-based theory that all features of a daughter node must also be found in its mother or that a mother node's features must consist of the unification of its daughters' features. In fact, a moment's reflection is sufficient to show that the sign-based architecture would have been unnecessary if such a restriction held. If nonterminal nodes contained all and only the information present in the terminal nodes, then it would have sufficed to enter such information solely in terminal nodes. Repeating the information in nonterminal nodes would have been redundant. The only point of enriching nonterminal nodes with their own information content is that the information content of a nonterminal node differs from the information content of its immediate constituents.

Furthermore, it is quite straightforward to show that such a principle cannot be defended in any interesting way in general for features other than phonology. Consider for example the following morphological constructions in Turkish: one applies to nouns, and verbalizes them by adding the suffix *-lʲe ~ -la*:

(367)	imzaː	'signature'
	imzaː-la	'sign (V)'
	tuz	'salt (N)'
	tuz-la	'salt (V)'

The other applies to verbs, and nominalizes them by adding the suffix *-iʃ ~ -ɯʃ*:

(368) ɪmzɑː-lɑ-jɯʃ ‘a signing’
tuz-lɑ-jɯʃ ‘a salting’

gʲelʲ ‘come’
gʲelʲ-iʃ ‘a coming’

Now, if we wanted to hold that the mother’s category feature had to be identical to its daughter’s (in accordance with a categorial analog of Bird and Klein’s Principle of Compositionality), we would have to posit that in the lexicon, both roots *imzaː* ‘signature’ and *gʲelʲ* ‘come’ are specified for a disjunction of the features *verb* and *noun* (since words containing these suffixes can be verbs or nouns). But now we have no way expressing the contrast that one is a verb and the other is a noun, since they both have exactly the same lexical feature specification. We must conclude that no Principle of Compositionality can possibly hold on the percolation of syntactic category features.[73] Thus even if a Principle of Compositionality did hold on phonological features, it would be stipulated, rather than inevitable. That is, it is untenable to argue that the spirit of unification-based theories requires the principle of phonological compositionality (since analogous principles do not hold on syntactic and semantic features). The principle of phonological compositionality reduces to a stipulation specific to phonology. If such a principle could indeed be shown to hold on phonology (while it does not hold on syntactic and semantic information), this would be somewhat of an embarrassment for the unification-based approach, and a return to Lieber’s hybrid model (where phonology is modeled in a terminal-based fashion, but all other information is treated in a sign-based fashion) would perhaps be warranted.[74]

I conclude therefore that Bird and Klein 1994’s principle of compositionality is not only not required by the spirit of unification-based theories, but is in fact very much counter to that spirit. The approach adopted in this work, which essentially states that mother node features are related to daughter node features by a set of constraints is in the spirit of a constraint-based theory. The nature of these constraints is of course the subject matter of phonological theory. I have used Optimality Theory as my phonological theory in this study, but for the computationally oriented, the Finite State Transducer based approach of Krieger et al. 1993 is an attractive alternative.

73 I show in section 6.4.2 that a very similar argument can be constructed specifically against the principle of phonological compositionality.

74 While Bird and Klein 1994 retain enough two-level tools that their approach cannot be justly considered terminal-based, the approach taken by Cole and Coleman 1993, Walther 1995 can be regarded as equivalent to a terminal-based treatment of phonology within an otherwise explicitly sign-based framework.

6.4.2 Bengali laryngeal assimilation

In this section, I will construct an empirical argument against the principle of phonological compositionality based on laryngeal assimilation in Bengali (Kenstowicz 1994), where coda consonants assimilate to the laryngeal features of following onset consonants (369):

(369)	a)	ʃɑt	bʰɑli	ʃɑdbʰɑli
		'seven'	'brothers'	
	b)	mɔd	kʰɑoɑ	mɔtkʰɑoɑ
		'alcohol'	'drinking'	

To handle the alternation in (369a), we may posit that lexically, this root is specified for a disjunction between a final [t] and a [d]. Note that underspecification will not be sufficient here, since too many laryngeal contrasts are neutralized (370):

(370)	ʃɑt	bʰɑli	ʃɑdbʰɑli
	'seven'	'brothers'	
	pɔtʰ	dækʰɑ	pɔddækʰɑ
	'road'	'seeing'	

The representation of the root *ʃat* 'seven' will then be as shown in (371):

(371) PHON ⟨ʃɑ{t, d}⟩

Next, consider the root in (369b). For similar reasons, this root will also have to be specified for a disjunction between a final [t] and [d]. The phonological specification of this root is given in (372):

(372) PHON *mɔ*{*t, d*}

Notice that in our attempt to model an apparently structure-changing alternation in one-level terms, we have lost the contrast between the two lexical forms. There is no way to recover the non-preconsonantal contrast the two roots exhibit (*ʃat* versus *mɔd*). Whatever constraint we devise to force *ʃat* to appear with a [t] will also cause *mɔd* to appear with one, resulting in **mɔt*. Conversely, if we posit a constraint that handles *mɔd*, then we will also predict **ʃad*. We somehow need to indicate that one of the disjuncts is the "preferred" one, that is, the one that will surface unless some constraint forces the other one to surface. But that would be equivalent to specifying the lexical representation for the "preferred" variant, and letting the responsible grammatical constraint override this

specification. Since overrides have to be allowed anyway (as I have shown in section 6.3), we might as well give up the principle of compositionality.

I conclude that one-level phonology, although computationally attractive, is not empirically adequate as a theory of phonology. Nor is it required by the letter or spirit of a constraint-based grammar framework. The only remaining objection to two-level approaches presented by Bird and Ellison 1994, Bird and Klein 1994 is based on their rule orientation. Since rule-based theories emphasize processes rather than output structures, they tend to lose generalizations concerning wellformed output structures. This is the well-known issue of conspiracies. This criticism, however, does not apply to all two-level theories. In particular, Optimality Theory is a two-level approach to phonology that does not lose explanatory power in this way, as I have discussed in Orgun 1996a. See also McCarthy 1996b for a particularly lucid discussion of this issue.

Chapter 7. Conclusion

I started this study with a list of desiderata for a theory of the phonology-morphology interface. Existing theories of the phonology-morphology do not satisfy these desiderata too well. This has been my main motivation for developing Sign-Based Morphology. In this chapter, I return to the desiderata and show that Sign-Based Morphology indeed satisfies each one in a principled fashion. I repeat those desiderata here:

(373)
a) Account for cyclic phonological effects
b) Account for noncyclic phonological effects
c) Relate the cyclic-noncyclic contrast to independently motivated morphological properties of words
d) Predict the inside-out nature of cyclic effects
e) Account for Bracket Erasure effects (do not allow unlimited reference to the internal structure of words by the grammar)
f) Handle challenges to Bracket Erasure
g) Account for "level economy" effects (the exemption of forms from the phonology of levels where they do not undergo morphology) and other departures from level ordering
h) Use only independently motivated analytical tools

The theory developed in this thesis, Sign-Based Morphology, is a declarative, unification-based approach to morphology. It satisfies each of the desiderata above.

It derives cyclic and noncyclic phonological effects from branching and flat constituent structures, respectively. In Turkish, the flat and branching structures motivated by the apparent cyclic versus noncyclic application of a disyllabic minimal size condition match the structures motivated by Suspended Affixation.

Unlike paradigmatic approaches to the phonology-morphology interface, Sign-Based Morphology predicts the inside-out nature of interleaving (cyclicity and level ordering) effects. Simple forms are never affected by complex forms, because complex forms are not constituents in the structure of simple forms.

Bracket Erasure effects are handled in Sign-Based Morphology without any brackets or any erasure. They follow from the assumption that no morphological information whatsoever is represented within phonological strings. This lack of morphological information in phonological strings is desirable regardless of Bracket Erasure effects, since there are serious problems with such segmentation of phonological strings into morphs.

Challenges to Bracket Erasure are handled by reference to lexical types. Types are used extensively in unification-based theories of grammar to capture generalizations, and to impose conditions on classes of objects. Thus, type hierarchies are independently motivated; they are not an ad-hoc tool introduced to encode some morphological structure information within signs. The Sign-Based Morphology approach to reference to lexical types makes an interesting and novel prediction: the identity, but not the location, of the outermost morphological construction (in terms of constituent structure) within a form

can be accessed by the morphology. Other theories of morphology either allow no access at all to morphological structure (too little information), or access to the identity as well as the location of a morpheme within a form (too much information, as I claim that the location is never relevant to the grammar). Only Sign-Based Morphology captures this new contrast between phonology and morphology that I have revealed by careful examination of apparent violations of Bracket Erasure effects.

In Sign-Based Morphology, the application of phonology is dependent on morphological constructions. Phonology relates the mother node's phonological string to its daughters' strings. This construction-driven understanding of phonology paves the way to successful handling of level economy, looping, and other departures from level ordering.

Sign-Based Morphology does not use any ad-hoc mechanisms. All the tools used have ample independent motivation.

Cyclic effects follow from constituent structures and feature percolation. Percolation is used in every theory that uses constituent structures. The Sign-Based Morphology technique of including phonology in the scope of percolation cannot be regarded as an added tool. On the contrary, it gives rise to a more coherent theory than, say, Lieber's, where every type of information except phonology is subject to percolation.

The other main analytical device in Sign-Based Morphology is lexical types. Not only are those common in unification-based theories, they also serve a number of useful functions in morphological theory proper. For example, as Riehemann 1993, Inkelas and Orgun 1994, Koenig and Jurafsky 1994, Riehemann 1994, and Inkelas and Orgun 1995 show, they provide perhaps the only workable way to deal with marginally productive and unproductive morphology in a constituent structure-based morphology. Since lexical types are useful for so many different purposes, it should be considered fortunate that the grammar turns out to make reference to them. Any information encoded within lexical items but never accessed by the grammar is suspect. The demonstration in this thesis that reference to lexical types provides a principled and tightly constrained tool to deal with apparent challenges to Bracket Erasure provides further support to unification-based theories with type hierarchies.

Sign-Based Morphology thus satisfies all of our desiderata. Furthermore, it compares favorable to alternative approaches to morphology.

Lexical Phonology also deals with cyclic and (by stipulation) noncyclic phonology. It accounts for Bracket Erasure effects by stipulation. It handles departures from level ordering in a brute-force fashion by introducing additional tools. It has no principled way to deal with apparent violations of Bracket Erasure.

Lieber's constituent structure-based view of morphology provides many of the insights that Sign-Based Morphology utilizes. Like Sign-Based Morphology, Lieber's theory makes extensive use of feature percolation. Like Sign-Based Morphology, Lieber represents affixes as partial words, that is, as constituent structures with an unspecified stem. Sign-Based Morphology differs from Lieber in including phonology in the scope of percolation. This allows Sign-Based Morphology to offer a more satisfactory account of nonconcatenative morphology, which Lieber is forced to relegate to a separate, transformational, component of the lexicon.

Like realizational approaches to morphology, Sign-Based Morphology offers a uniform treatment of concatenative and nonconcatenative morphology. However, Sign-Based Morphology is better able to handle an important difference between the two types of morphology: by introducing affixal (and, in general, "marker") material as a fixed argument to the phonological function that relates mother and daughter nodes, Sign-Based Morphology is able to impose more restrictions on the theory of phonology. In particular, phonological deletion, just like morphological subtraction, targets tightly restricted packages of material (usually characterized as a single metrical constituent). Phonological insertion is similarly restricted. However, morphological insertion (that is, affixation) is not restricted in the same way. Affixes may introduce arbitrary amounts and types of phonological material (e.g., Turkish *-dʒesine*, and adverbializing suffix that attaches to nouns, or *-mturak*, a diminutive suffix that attaches to adjectives). Traditional realizational approaches therefore have to allow insertion of arbitrary amounts of phonological material. But this leads to the loss of the important generalization that phonology never introduces such material.

Sign-Based Morphology has a plausible paradigmatic interpretation. A constituent structure can be seen as a statement of relationships between signs, each of which exists as an actual (stored) or potential (one that can be licensed by constructions) lexical form. However, the similarities between Sign-Based Morphology and other paradigmatic approaches to morphology end here. Other paradigmatic approaches have no satisfactory way of dealing with both cyclic and noncyclic phonological effects. They do not predict the inside-out nature of interleaving effects. Most paradigmatic approaches to morphology are word-based. As such, they are unable to deal with bound complex stems that function as cyclic phonological domains, such as the Bantu verb stem.

Sign-Based Morphology combines insights from item-and-arrangement, item-and-process, and word-and-paradigm style approaches to morphology. Those approaches are usually thought to be radically different from, and incompatible with, each other. Sign-Based Morphology shows that this is a misconception. Its unique combination of insights from all these approaches allows it to account for a wider range of phenomena in a more principled fashion than other theories.

Several issues remain to be studied. The most obvious one is the question of bracketing paradoxes, that is, mismatches between morphologically and phonologically motivated constituent structures. While I have addressed some phenomena that could be considered Bracketing Paradoxes in chapter 5, a comprehensive study still remains to be conducted.

Another important area of research I have not touched on is the phonology-syntax interface.

Finally, more work on the cognitive and computational aspects of Sign-Based Morphology promises to be interesting.

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Index of languages and language families