Vowel Harmony and Stem Identity[*]

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> One of the most important tests that any theory of a given descriptive domain must pass is its ability to treat the apparent idiosyncrasies of the data; a theory which is able to extract significant generalities from such irregularities is more adequate (all else being equal) than one which is not.
>
> Clements (1976 [1980]:61)

1   Introduction

Vowel harmony is a phonological process by which neighboring vowels some domain (typically, the word) agree with each other in terms of some distinctive feature (or features), hereafter referred to as the *harmonic feature*. In many languages with a vowel harmony process, the harmonic feature appears to propagate outward from the innermost morphological constituent, henceforth referred to as the *root*. In the most straightforward case, the harmonic feature values of any and all affix vowels simply alternate in agreement with the harmonic feature value of the nearest vowel of the root to which the affixes are attached. This oversimplified description is schematized in the diagram in (1), where '$[\alpha hf]$' represents the value of the harmonic feature underlyingly specified on the root vowel '$\sqrt{V}$' and the arrows represent the propagation of $[\alpha hf]$ outward from $\sqrt{V}$ to the affix vowels of the word.

(1)   Root-outward vowel harmony, schematized

$$[V_{pfx} [V_{pfx} [[[\sqrt{V}] V_{sfx}] V_{sfx}] V_{sfx}]]$$
$$\leftarrow\leftarrow\leftarrow\leftarrow\leftarrow[\alpha hf]\rightarrow\rightarrow\rightarrow\rightarrow\rightarrow$$

In less straightforward cases, there are some affix vowels that for some reason or another do not alternate harmonically. Nonalternating vowels of this kind are referred to as *opaque*, and their behavior is referred to as *opacity*. Alternating vowels further from the root than an opaque affix vowel alternate to agree with the opaque vowel, but crucially, no vowel closer to the root is ever forced to agree with an opaque affix vowel — even if complete harmony is at stake. This is schematized in (2). (Please note that the affixes depicted in this diagram are somewhat arbitrarily represented as suffixes, but they could just as well be prefixes — what matters here is their position relative to the root vowel $\sqrt{V}$.)

(2)   Root-outward opacity, schematized

$$[[[[[[\sqrt{V}] V_{afx}] V_{afx}] V_{afx}] V_{afx}] V_{afx}]$$
$$[\alpha hf]\rightarrow\rightarrow[-\alpha hf]\rightarrow\rightarrow [\alpha hf]\rightarrow\rightarrow$$

Vowel harmony processes of the kind under discussion are commonly referred to in the phonological literature as *root-controlled*. Kirchner (1993:17) refers to them "more precisely" as *stem-controlled*, specifically due to opacity as just discussed. Kirchner's implicit definitions, which I adopt explicitly here, are that (i) a *stem* is any morphological constituent to which an affix may attach and that (ii) a *root* is the innermost stem. Seen in this light, the term *stem-controlled* does in fact express a more precise characterization of this type of vowel harmony process: an alternating affix vowel agrees with the vowel in the adjacent syllable[1] of the *stem* to which the affix is attached, whether this stem vowel is a root vowel or another affix vowel. The above notwithstanding, I will continue to use what I hope to be the more neutrally descriptive term *root-outward vowel harmony* to refer to this kind of vowel harmony process, simply because the more familiar terms *root-/stem-controlled* might tend to evoke some particular types of analyses over others.

In this article, I propose that the basic behavior of root-outward vowel harmony is due to a particular kind of interaction between phonology and morphology. My basic claim is that root-outward vowel harmony is to be understood exactly as follows: given the vowel of an affix and the adjacent vowel of the stem to which that affix is attached, root-outward vowel harmony systematically fails to affect the stem vowel in an explicit effort to achieve *stem identity*. This is schematized in (3).

(3)   Root-outward vowel harmony = stem identity, schematized

stem affixation (morphology)	*candidate affixed forms* (phonology)	*comments*
	$\rightarrow$ $\ \ $ [[V$_{stem}$] V$_{afx}$] $[\alpha hf]$ $[-\alpha hf]$	✓ *stem identity* ✗ *harmony*
[V$_{stem}$] + V$_{afx}$ $[\alpha hf]$ $\ \ $ $[-\alpha hf]$	$\rightarrow$ $\ \ $ [[V$_{stem}$] V$_{afx}$] $[\alpha hf] \rightarrow \rightarrow$	✓ *stem identity* ✓ *harmony*
	$\nrightarrow$ $\ \ $ * [[V$_{stem}$] V$_{afx}$] $\leftarrow \leftarrow [-\alpha hf]$	✗ *stem identity* ✓ *harmony*

In this schematic diagram, a (possibly complex) stem is affixed in the morphological component. The adjacent vowels between the stem and the affix are assumed to be underlyingly specified for opposing values of the harmonic feature [±*hf*]. (Although the linear order in this diagram implies that the affix is a suffix, it could just as well be a prefix.) The phonological component generates three relevant candidate realizations of this affixed form: the first with the opposing harmonic feature values of the stem and affix vowels unchanged, the second with the affix alternating to agree with the stem, and the third with the stem alternating to agree with the affix. As indicated by the comments in the right-hand column, the ideal result would be to achieve both stem identity and harmony, as in the second candidate form. However, this result is impossible just in case the affix vowel is a nonalternating opaque one. In such a case, stem identity always trumps harmony: the first, disharmonic candidate is the result because the third (shaded) candidate fails to achieve stem identity.

The basic arguments for the stem identity analysis of root-outward vowel harmony are presented in this article in as framework-independent a manner as possible, but for the sake of explicitness I present a specific incarnation of the analysis within Optimality Theory (OT, Prince & Smolensky 1993). Stem identity is formalized in terms of an asymmetric faithfulness relation between affixed forms and their morphological subconstituents, as developed in Transderivational Correspondence Theory (TCT, Benua 1997; see also Kager 1999ab and Kenstowicz 1996), which is based on the Correspondence Theory of faithfulness proposed by McCarthy & Prince (1995, 1999). I frame the analysis in terms of Benua's TCT mostly for illustrative purposes; as far as I can tell, the basic analysis is in principle compatible with any of the variety of alternative implementations of the cycle that have been proposed in the OT literature

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[1] Modulo transparent vowels; see the discussion surrounding footnote 13.

(e.g., Burzio's (2002) Surface-to-Surface Morphology, Orgun's (1996) Sign-Based Morphology, Kiparsky's (2000, to appear) LPM-OT, among others), all of which rely in some way on what amounts to an asymmetric faithfulness relation between affixed forms and their stems of affixation.[2] I henceforth restrict citation to Benua's work with this caveat firmly in mind.

Benua's basic proposal is that there is a correspondence relation between candidate realizations of a given stem$_i$ + affix$_j$ combination and the optimal realization of stem$_i$ alone.[3] A set of faithfulness constraints is defined on this correspondence relation, asymmetrically demanding that affixed forms be identical to their stems of affixation. My own claim with respect to root-outward vowel harmony is that when the constraint responsible for harmony is dominated by the faithfulness constraint demanding that affixed forms be identical to their stems in terms of the harmonic feature, the basic result is that agreement between stem and affix vowels is enforced only to the extent that stem-affixed form faithfulness can be respected. Thus, only affix vowels will alternate in agreement with stem vowels, as in (3).

I argue for the superiority of this stem identity analysis over alternative approaches to root-outward vowel harmony that appeal to one or both of the familiar analytical mechanisms of *directionality* and *underspecification*, described in (4) below. Each of these mechanisms has been implemented in slightly different ways — and very often in combination with each other — within actual analyses in the literature; the brief description accompanying each one in (4) represents what I consider to be its essential core regardless of its precise implementation.

(4)   Familar alternatives to stem identity

   a.   <u>Directionality</u>. The vowel harmony process is stipulated as operating from left to right or from right to left.

   b.   <u>Underspecification</u>. Alternating vowels are stipulated to be underlyingly unspecified for either value of the harmonic feature.

The article is organized as follows. In §2, I present some basic root-outward vowel harmony data and make explicit the three competing hypotheses for their analysis: first directionality, then underspecification, and finally stem identity. I also demonstrate how the stem identity analysis more directly characterizes the basic character of root-outward vowel harmony. I elaborate on the specifics of the stem-affixed form faithfulness implementation of stem identity in §0, and in §4 I make an additional set of arguments for the superiority of the stem identity approach based on its uniquely parsimonious account of vowel opacity. In §5, I compare the proposed stem-affixed form faithfulness analysis with two alternative implementations of stem identity that have been proposed elsewhere in the literature. I conclude in §6 with a brief summary of some of the article's key points.

2   Analyses of root-outward vowel harmony

2.1   Directionality

The data in (5) below represent examples of root-outward vowel harmony in Tangale, a Western Chadic language (Kidda 1985, van der Hulst & van de Weijer 1995). In Tangale, root vowels are constant and suffix vowels generally alternate in terms of the harmonic feature [±ATR] (Advanced Tongue Root). <u>Un-</u>

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[2] There is too much relevant work to cite exhaustively here, never mind to compare and contrast explicitly. See McCarthy 2002:184-185 for more references, under the headings "The Cycle" and "OT and Lexical Phonology".

[3] An additional condition imposed by Benua (1997) is that stem-affixed form faithfulness holds only between stems and affixed forms that constitute *independent words* (hence Benua's term *output-output faithfulness*). This assumption is justified in large part by the claim that bound roots do not constitute cyclic domains (Brame 1974, Kiparsky 1982, Selkirk 1982, Inkelas 1989; see also Kenstowicz 1996, Kager 1999ab, and Bakovic 1998). For reasons discussed at length in Bakovic 2000:70-73, I do not adopt this additional condition here.

derlining in the underlying representations on the left in each example (redundantly) highlights the root vowel instigating harmony, and in the surface representations on the right it indicates the propagation of the harmonic feature throughout the word.

(5)   Tangale root-outward [±ATR] harmony

    a.   /√t<u>u</u>g + O/   →   [t<u>ugo</u>]   *[+ATR] root*
            pound + NOM   'pounding'

    b.   /√w<u>ʊ</u>d + O/   →   [w<u>ʊdɔ</u>]   *[–ATR] root*
            farm + NOM   'farming'

    c.   /√ɗ<u>o</u>b + Um + gU/   →   [ɗ<u>obumgu</u>]   *[+ATR] root*
            call + 1PL + PERF.PL   'called us'

    d.   /√t<u>ɛ</u>ŋl + Un + gO/   →   [t<u>ɛŋlʊŋɔ</u>]   *[–ATR] root*
            mislead + 1SG + PERF.SG   'misled me'

Because root vowels are harmonically constant, they are represented with relatively definitive IPA symbols in underlying representations; the [+ATR] vowels are *i, e, o, u* and the [–ATR] vowels are *ɪ, ɛ, ɔ, ʊ*. On the other hand, because affix vowels harmonically alternate, they are underlyingly represented with the less definitive capital letters *I, U, E, O*. Note, however, that no analytical significance is granted to the ambiguity of the alternating affix vowels compared to the nonalternating root vowels; I simply acknowledge that it is in general impossible to pretheoretically determine the underlying harmonic feature value of alternating vowels.[4]

Based on the data in (5), one interpretation of the root-outward [±ATR] harmony process in Tangale is that it operates directionally, *from left to right*: the harmonic feature value of the *leftmost* vowel of the word serves as the 'trigger' and all other vowels serve as the 'targets' of the [±ATR] harmony process.[5] A couple of alternative formulations of this interpretation are given in (6). (Ignoring details that are irrelevant to the issues at hand, these formulations do not exactly reflect actual proposals in the literature.[6]) Note that under this interpretation, the harmony trigger just happens to be the (initial) root vowel because there just happen to be no prefixes in Tangale.

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   [4] The underlying harmonic feature value of an alternating vowel can in fact sometimes be discerned from its surface form in nonalternating contexts, as in Hungarian (Vago 1973:593, Ringen & Vago 1998:395), where some alternating suffixes function also as nonalternating (and harmonically contrastive) roots. (For a recent opposing view on this matter, in reference to the same Hungarian facts, see Reiss 2003:216-217.)

   [5] It should be noted that neither Kidda (1985) nor van der Hulst & van de Weijer (1995) adopts a directional analysis of Tangale vowel harmony. Descriptively, these authors appeal directly to the distinction between what they call 'stems' (here, roots) and affixes: "The harmony of the stem is induced on the suffix" (Kidda 1985:93), "Stems […] are invariant […] and the affixes act like chameleons" (van der Hulst & van de Weijer 1995:496). Analytically, Kidda adopts an underspecification analysis; van der Hulst & van de Weijer don't propose any particular analysis.

   [6] Note that these rules (and those in (8) as well) would have to be applied either iteratively (Howard 1972) or persistently (Myers 1991) until their structural descriptions are no longer met.

(6)   Directional formulations of Tangale root-outward [±ATR] harmony

    a. $V \to [\alpha ATR] / [\alpha ATR] C_0$ __   *"linear" formulation*

    b.   V   C$_0$ V   *"nonlinear" or autosegmental formulation*

         [αATR] [βATR]

For comparison with Tangale, consider now the data in (7) below from Yoruba, a Benue-Congo language (Bamgbose 1966, Archangeli & Pulleyblank 1989, 1994). By contrast with Tangale, there are no suffixes in Yoruba, only prefixes.[7]

(7)   Yoruba root-outward [±ATR] harmony

    a.   /E + √we/   →   [ewe]   *[+ATR] root*
                                 'lip'

    b.   /E + √gɛ/   →   [ɛgɛ]   *[–ATR] root*
                                   'cassava'

    c.   /O + gE + √de/   →   [ogede]   *[+ATR] root*
                                   'incantation'

    d.   /O + gE + √dɛ/   →   [ɔgɛdɛ]   *[–ATR] root*
                                   'banana/plantain'

The Yoruba facts in (7) are clearly amenable to the same kind of directional interpretation as those in Tangale, but instead of from left to right, [±ATR] harmony in Yoruba must apply *from right to left*: the harmonic feature value of the *rightmost* vowel of the word is the trigger and all other vowels are the targets.[8] Alternative formulations of this interpretation are given in (8) below. Note again that under this interpretation, the harmony trigger in Yoruba just happens to be the (final) root vowel because there happen to be no suffixes in the language.

(8)   Directional formulations of Yoruba root-outward [±ATR] harmony

    a. $V \to [\alpha ATR] /$ __ $C_0 [\alpha ATR]$ *"linear" formulation*

    b.   V   C$_0$ V   *"nonlinear" or autosegmental formulation*

         [βATR] [αATR]

2.2   Underspecification

Clements (1976 [1980], 1977, 1981) argues that languages with *both* prefixes and suffixes provide compelling evidence against raw directionality in the analysis of vowel harmony. Consider the data in (9) below from Akan, a Kwa language (Shachter & Fromkin 1968, Clements 1981).

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[7] In many cases there is not much synchronic evidence, apart from vowel harmony, for the morphological decomposition of polysyllabic forms in Yoruba — hence the lack of interlineal glosses for the examples in (7). Nevertheless, the claim that all polysyllabic forms are morphologically decomposable into prefixes and roots is independently made and supported by Adetugbo (1967), Fresco (1970), Awoyale (1974), and Akinkugbe (1978). Many thanks to Akin Akinlabi for bringing these works to my attention, and for much discussion of Yoruba in general.

[8] This is more or less the analysis of Yoruba adopted by Archangeli & Pulleyblank (1989, 1994), though these authors also argue for the crucial use of underspecification — see §4.4.2.

(9)   Akan root-outward [±ATR] harmony

a.	/E + √bu̱ + O/	→	[ebuo]	*[+ATR] root*
	CLASS + nest + SFX		'nest'	
b.	/E + √bu̱ + O/	→	[ɛbʊɔ]	*[–ATR] root*
	CLASS + stone + SFX		'stone'	
c.	/O + bE + √tu̱ + I/	→	[obetui]	*[+ATR] root*
	3SG + COME + dig + PAST		'he came and dug (it)'	
d.	/O + bE + √tu̱ + I/	→	[ɔbɛtʊɪ]	*[–ATR] root*
	3SG + COME + throw + PAST		'he came and threw (it)'	

Just as in Tangale and Yoruba, affix vowels in Akan alternate in harmonic agreement with constant root vowels. The defender of directionality must concede either that there is a bidirectional ("mirror-image") [±ATR] harmony process, or else that there are two unidirectional processes of [±ATR] harmony, one left-to-right and the other right-to-left.[9] Note that in either case, the fact that harmony proceeds outward from the root must be independently stipulated.

As an alternative to directionality, Clements stipulates a specificational distinction between nonalternating (root) vowels and alternating (affix) vowels: the former are underlyingly specified for some value of the harmonic feature, while the latter are underlyingly underspecified for any value of this feature.[10] Harmony then proceeds not by directional rule but by an extension of Goldsmith's (1976 [1979]) well-formedness condition: all vowels must be associated with a value of the harmonic feature, which therefore spreads, nondirectionally, from the specified (root) vowels to the underspecified (affix) vowels. Apart from the fact that the distinction between root and affix is indirectly — and arbitrarily — stipulated, we will see in §4 that significant vestiges of directionality typically remain in underspecification analyses, as well as vice-versa.

2.3   Stem identity

The fact that the 'direction' of harmony observed in Tangale and Yoruba correlates precisely with the asymmetrical morphological structure of words in each of these languages already raises suspicion about the postulation of an independent directional mechanism in the analysis of vowel harmony. Harmony only *seems* to emanate from the left in Tangale words, because the root is always on the left. Likewise, harmony only seems to emanate from the *right* in Yoruba words, because the root is always on the right. The additional fact that a language like Akan with symmetrical morphological structure exhibits bidirectional harmony confirms this suspicion: in words with both prefixes and suffixes, harmony seems to operate in both directions because the root is somewhere in the middle. The three situations are schematized in (10) below.

(10)   Directionality correlates with morphological structure

a. Tangale	b. Yoruba	c. Akan
[[[√CVC] VC$_{sfx}$] VC$_{sfx}$]	[V$_{pfx}$ [CV$_{pfx}$ [√CV]]]	[V$_{pfx}$ [[√CV] V$_{sfx}$]]
[αATR]→→→→→→	←←←←←←[αATR]	←←←[αATR]→→→

Once the morphological structure of a word is taken into account, the apparent need to independently stipulate either the directionality of the vowel harmony process or the relative specification of the vowels becomes superfluous. An explanatory account of root-outward vowel harmony should derive the

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[9] On the latter type of alternative, see Archangeli & Pulleyblank 1994:298*ff*; see also §4.6.

[10] Nonalternating (that is, opaque) vowels are analyzed as being specified, either by phonological rule or by lexical redundancy rule, for their value of the harmonic feature. I return to this point in §4.4.

differences in the behavior of harmony in each of these languages directly from their different morphological structures, and nothing else. An analysis based on directionality fails precisely because it cannot explain in principle why left-to-right directionality correlates with suffixation nor why right-to-left directionality correlates with prefixation. An analysis based on underspecification fares no better; the underlying underspecification of affix vowels as opposed to root vowels similarly fails to provide any insight as to *why* this distinction is made between root and affix vowels. Moreover, and as I show in detail in §4, actual analyses in the literature of necessity involve some mixture of both directionality and underspecification, leading to a serious duplication of efforts by these two independent mechanisms.

The alternative that I propose instead is that root-outward vowel harmony is a nondirectional process, operating on fully specified representations, that is subject to a condition requiring identity between an affixed stem and its unaffixed twin. The resulting [±ATR] harmony process of Tangale, Yoruba, and Akan is thus as stated in (11)a, and the stem identity condition that this process is subject to in all three of these languages is as stated in (11)b.

(11)   Stem identity interpretation of root-outward [±ATR] harmony

    a.   <u>Harmony</u>. Adjacent vowels of a word must (be made to) agree in their value of the harmonic feature [±ATR], subject to the stem identity condition in (b).

    b.   <u>Stem identity</u>. Given [*stem$_i$*] and [[*stem$_j$*] *afx*], where *afx* is a prefix or suffix and *stem$_i$* is morphologically identical to *stem$_j$*, application of a process P across the *stem$_j$* and *afx* boundary may not thereby render *stem$_i$* and *stem$_j$* phonologically distinct.

Note that the harmony process in (11)a makes no necessary reference to the specification or underspecification of vowels; any vowel is a potential trigger or target, and which is which is decided by the stem identity condition in (11)b. Note also that the harmony process is stated nondirectionally (compare the directional rules stated in (6) and (7)); adjacent vowels must agree, but there is no preference for which vowel is made to agree with the other — if they don't already happen to agree when the process applies. This is because the apparent directionality of root-outward harmony is taken here to be an illusion of the stem identity condition, which states that a process subject to the condition may only apply between a stem and an affix in such a way that the stem remains identical to the unaffixed instantiation of the same stem. The very same harmony process in (11)a can thus be held responsible for [±ATR] harmony in Tangale, Yoruba, and Akan, and the apparent differences among these languages derive directly from the stem identity condition in (11)b and the different morphological structures possible in each language.

2.4   Summary

In this section I demonstrated how the basic character of root-outward vowel harmony — originating in the root and emanating outward therefrom — follows in a direct way from the stem identity analysis but must be independently stipulated under directionality and/or underspecification analyses. It is worth noting here that the stem identity condition in (11)b is just a particular interpretation of a common observation made about certain phonological processes applying across morpheme boundaries; namely, that they function in such a way that the stem to which an affix attaches remains identical to its unaffixed twin in crucial respects. The essence of this observation has been formulated in various different ways throughout the history of generative phonology, from the transformational cycle (Chomsky, Halle & Lukoff 1956, Chomsky & Halle 1968) to the Strict Cycle Condition (Kean 1974, Mascaró 1976) to Lexical Phonology (Pesetsky 1979, Kiparsky 1982).[11] But as I show in more detail in the following section, the statement of the stem identity condition in (11)b more closely resembles the stem-affixed form faithful-

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[11] Kiparsky (2000, to appear) has continued to develop Lexical Phonology, *mutatis mutandis*, within OT.

ness constraints of TCT (Benua 1997), and the blocking interaction between stem identity and the generalized root-outward vowel harmony process in (11)a follows naturally from constraint ranking in OT.

　　Although I argue for and maintain the position throughout this article that stem identity renders directionality and underspecification superfluous in the analysis of root-outward vowel harmony, I leave open two questions that are equally important but logically separable from this position. The first question is whether some variety of directionality or underspecification is independently necessary in the analysis of vowel harmony that is not root-outward (or of any such featural process for that matter, but we focus on vowel harmony here). If the answer to this first question is affirmative, then the second question is how to accommodate these mechanisms within phonological theory such that the positive results claimed in this article to derive from stem identity alone still hold.

　　Consider first the case of directionality. Restricting our attention to very recent work, Krämer (2001, 2003), Archangeli & Pulleyblank (2002), Hyman (2002), Pensalfini (2002), and Walker (2002) all discuss patterns of vowel harmony that are apparently directional and not root-outward, and that are thus prima facie counterexamples to the strong claim that directionality plays no role in the analysis of vowel harmony. Interestingly, however, each of these authors proposes an account in which directionality is not a primitive, essentially addressing a part of the second question noted above. One of my aims in the present article is very much in the same spirit as the proposals made by these and other authors: to curtail the power of pure directionality, and to ascribe its apparent effects to other, independently motivated mechanisms — in the case of root-outward vowel harmony as understood in the present work, to stem identity.

　　Consider now the case of underspecification. A decade has passed since the appearance of three important critiques of underspecification — Mohanan 1991, McCarthy & Taub 1992, and Steriade 1995 — and the demonstration by Smolensky (1993) that OT's conception of markedness obviates underspecification (see also Artstein 1998, for which vowel harmony in Yoruba serves as the empirical vehicle). Again, this is all perfectly consonant with another one of my aims in this article: to show that underspecification is, at best, unnecessary in the analysis of an empirical domain for which it has been argued to be indispensable in the past.

3　　Stem-affixed form faithfulness

The main ingredient of the Transderivational Correspondence Theory (TCT) approach to root-outward vowel harmony developed in what follows is the asymmetrical correspondence relation between affixed forms and their stems of affixation. Before exploring the details of this main ingredient, however, let us introduce the other crucial ingredients of the analysis. The most important of these is the set of constraints demanding harmony. Following work on voicing assimilation by Lombardi (1996ab, 1999), I propose the family of agreement constraints defined in (12).[12]

(12)　AGREE[±*hf*]
　　　Adjacent segments have the same value of [±*hf*].

　　An agreement constraint is violated once for each transition in an output string of adjacent segments from one value of the relevant feature to the other value. Vowels are assumed to be adjacent, in the sense relevant to agreement constraints, across intervening consonants; since issues of assimilatory locality are not my focus in this article, I henceforth ignore consonants altogether and attend solely to adjacent vowels. Relatedly, I also ignore what are known as *transparent vowels*. Like opaque vowels, transparent vowels do not alternate; unlike opaque vowels, transparent vowels appear to allow the opposite value of

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[12] Gnanadesikan's (1997) ASSIM and Krämer's (1999, 2000, 2001) S-IDENT constraints are identical to the agreement family in most respects, as is the basic spirit of Pulleyblank's (1997) IDENTICAL CLUSTER constraints. An interesting possiblity that I do not investigate here is that agreement could be more monolithic, demanding that adjacent segments agree in terms of a *feature class* (as in Padgett 1995ab) or in terms of *all* features (as in Kirchner 1993). Under either approach, better satisfaction of agreement would be gained gradiently for each agreeing feature.

the harmonic feature to pass through them, resulting in doubly-disharmonic forms. Henceforth, then, when I use the term 'adjacent vowel', I mean 'nearest nontransparent vowel'.[13]

The fundamental difference between languages with a vowel harmony process and those without lies in the relative ranking between a particular AGREE[±*hf*] constraint — where [±*hf*] is a (potentially) harmonic vowel feature — and the faithfulness constraint regulating identity between input and output segments in terms of [±*hf*]. Following McCarthy & Prince (1995, 1999), these faithfulness constraints are predicated on a correspondence relation that is established between the segments of an input and the segments in the set of output candidates for that input.

(13) IO-IDENT[±*hf*]
     Corresponding input and output segments have the same value of [±*hf*].

For languages in which IO-IDENT[±*hf*] dominates AGREE[±*hf*], the feature [±*hf*] is not a harmonic one; vowels preserve their underlying (and often disharmonic) specifications at the expense of agreement. For languages in which AGREE[±*hf*] dominates IO-IDENT[±*hf*], on the other hand, [±*hf*] is potentially harmonic: given two adjacent vowels that differ underlyingly in terms of [±*hf*], the underlying specification of one of those vowels may be sacrificed to satisfy agreement at the expense of faithfulness.

Now note that agreement constraints are directionally symmetrical. AGREE[±*hf*] itself cannot distinguish between an output candidate in which a vowel V1 alternates to agree with an adjacent vowel V2 and another output candidate in which V2 alternates to agree with V1. The distinction between these two candidates is made by other constraints; in the case of root-outward vowel harmony, I claim that the distinction is made by constraints enforcing stem identity, the main ingredient to which we now turn.

In TCT, a correspondence relation is established not only between input and output but also between the segments of affixed forms and the respective segments of their stems of affixation (independently-occurring or not; see footnote 3). This relation is subject to an independent set of faithfulness constraints regulating identity between these corresponding segments; to distinguish them from input-output (IO-) faithfulness constraints, I refer to them as stem-affixed form (SA-) faithfulness constraints.

(14) SA-IDENT[±*hf*]
     Corresponding stem and affixed form segments have the same value of [±*hf*].

In order to evaluate a given candidate affixed form with respect to a stem-affixed form faithfulness constraint, it must be the case that every stem is derived in some sense *prior* to the derivation of every affixed form based on that stem. In this respect, TCT is a direct successor to the transformational cycle (Chomsky, Halle & Lukoff 1956, Chomsky & Halle 1968): evaluation of affixed forms must proceed cyclically, from the root outwards. Herein lies the necessity for the asymmetry of stem-affixed form faithfulness constraints: they evaluate affixed forms with respect to their stems, not vice-versa. This asymmetry, dubbed 'priority of the base' by Benua (1997), is accounted for in TCT by subjecting each affixed form to a lower-ranked recursion of the constraint hierarchy than its stem. The desired result can also be achieved by applying the constraint hierarchy to an affixed form cyclically; i.e. serially, from the innermost morphological constituent outward (see Benua 1997:83*ff*). I take no position on these alternatives here; I simply stipulate that an affixed form has access to the (already-evaluated) output form of its stem of affixation, but not vice-versa, for the purposes of evaluation by SA-IDENT[±*hf*] constraints.

These three constraint types — agreement, input-output faithfulness, and stem-affixed form faithfulness — form the core of the analysis of root-outward vowel harmony. As noted above, agreement must dominate faithfulness in order for there to be harmony in the first place; stem-affixed form faithfulness breaks the tie between candidates that better satisfy agreement.

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[13] See Gafos 1996, 1998, Ní Chiosáin & Padgett 1997, 2001, Walker 1998, Bakovic & Wilson 2000, Krämer 2001, Kiparsky & Pajusalu 2002, Lewis 2002, and Pulleyblank 2002 for recent discussion of these and other locality-related issues in the analysis of vowel harmony.

(15)   Root-outward vowel harmony

Input: $[\ V_{stem}\ ] + V_{afx}$
$[\alpha hf]\quad[-\alpha hf]$

Candidates		AGREE[±*hf*]	IO-IDENT[±*hf*]	SA-IDENT[±*hf*]
a.	$[\ [\ V_{stem}\ ]\ V_{afx}\ ]$ $[\alpha hf]\ [-\alpha hf]$	*!		
b. ☞	$[\ [\ V_{stem}\ ]\ V_{afx}\ ]$ $[\alpha hf]\rightarrow\rightarrow$		*	
c.	$[\ [\ V_{stem}\ ]\ V_{afx}\ ]$ $\leftarrow\leftarrow[-\alpha hf]$		*	*!

Some remarks on the evaluation of the candidate outputs in this tableau are in order. The first candidate in (15)a is the input- (and stem-) faithful candidate, but it fails miserably on agreement since the two adjacent vowels of the form do not agree in terms of the harmonic feature. Because AGREE[±*hf*] dominates IO-IDENT[±*hf*], this candidate is ruled out. The competition narrows down to the remaining two candidates, each of which satisfies AGREE[±*hf*] in a different way: the second candidate in (15)b is unfaithful to the affix vowel while the third candidate in (15)c is unfaithful to the stem vowel. This results in a tie on IO-IDENT[±*hf*], but the additional violation of SA-IDENT[±*hf*] by the stem-unfaithful candidate proves to be fatal for it.

Note that the ranking of SA-IDENT[±*hf*] relative to the other two constraints is irrelevant to this particular evaluation; this is what is meant to be indicated by the bolder line separating this constraint from the other two. The relative ranking of SA-IDENT[±*hf*] becomes crucial, however, when root-outward harmony is blocked by an opaque vowel, as made clear in §4 below.

4   Stem precedence

Recall Kirchner's (1993) observation from §1 that, based on the behavior of opaque vowels, it is more accurate to say that the stem rather than the root 'controls' root-outward harmony. In this section I elaborate on this point and demonstrate how the proposed stem identity analysis — and more specifically, the stem-affixed form faithfulness implementation thereof — accounts directly for the right generalization behind opacity, which I refer to as the *stem precedence generalization*. The alternative directionality and underspecification analyses are not so successful at capturing this generalization, as I also demonstrate.[14]

To begin, recall the schematic diagram in (2) above, repeated in (16) below. The second and fourth affix vowels in this diagram represent opaque affix vowels; the remaining affix vowels are alternating. The situation schematized in this diagram is the interesting, necessarily disharmonic case where each of these opaque vowels differs in its nonalternating harmonic feature specification from the next nonalternating vowel closer to the root.

(16)   Root-outward opacity, schematized

$[\ [\ [\ [\ [\ [\ \sqrt{V}\ ]\ V_{afx}\ ]\ V_{afx}\ ]\ V_{afx}\ ]\ V_{afx}\ ]\ V_{afx}\ ]$
$[\alpha hf]\rightarrow\rightarrow[-\alpha hf]\rightarrow\rightarrow\ [\alpha hf]\rightarrow\rightarrow$

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[14] I do not discuss Kirchner's (1993) account of the relevant generalization in the text because he himself states (on p. 17) that his proposal "should be regarded as a promissory note, rather than a serious attempt at explanation of the phenomenon of stem control." This is not a criticism of Kirchner's proposal; the goal of his work is an OT account of Turkish disharmony (Clements & Sezer 1982), not of root-outward vowel harmony more generally.

As indicated by the arrows, the first affix vowel, which is of course closer to the root than the opaque second affix vowel, alternates to agree with the root vowel and — crucially — not with the opaque vowel. Likewise, the third suffix vowel, which lies between the two opaque vowels, alternates to agree with the opaque vowel closer to the root. Finally, any alternating vowel further from the root than all nonalternating vowels (represented by the fifth affix vowel in the diagram), alternates to agree with the last nonalternating vowel. The harmonic fate of alternating affix vowels is thus attributable to the following overall generalization about root-outward vowel harmony.

(17)   Stem precedence generalization

An alternating affix vowel always agrees with the adjacent vowel in the stem to which the affix is attached.

As I demonstrate in this section, the stem precedence generalization in (17) follows most parsimoniously from the stem identity analysis of root-outward vowel harmony. Under both the directionality and underspecification analyses, the generalization must be independently — and often unsuccessfully — stipulated. Before proceeding with the demonstration, I first explain the conditions under which affix vowels are found to be nonalternating (specifically, opaque) in languages with vowel harmony.

4.1   Harmonic pairing and opacity

In a language with a vowel harmony process, there are typically some vowels that do not alternate as expected. Vowels of this kind are sometimes simply unpredictable peculiarities of certain morphemes. More often and interestingly, a vowel will not alternate as expected because it is not *harmonically paired*. A definition of harmonic pairing is provided in (18) below.

(18)   *Definition.* Harmonic pairing.

A vowel *x* in a language L with a harmonic feature [±*hf*] is harmonically paired iff there is another vowel *y* in L's inventory and *y* differs from *x* only in terms of [±*hf*].

For example, in languages with [±ATR] harmony, mid vowels are typically harmonically paired: [+ATR] *e,o* exist alongside [−ATR] *ɛ,ɔ*; high vowels, on the other hand, are sometimes harmonically paired and sometimes not, depending on the language.[15] Tangale and Akan, for instance, have both [+ATR] *i,u* and [−ATR] *ɪ,ʊ*; Yoruba, on the other hand, lacks [−ATR] *ɪ,ʊ*. Finally, all three of these languages lack a [+ATR] counterpart for the low [−ATR] vowel *a*, which is thus harmonically unpaired.[16] The charts in (19) summarize the harmonic pairing situations for the three languages.

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[15] There are cases in which it has been reported that there is a [±ATR] contrast among high vowels but not among mid vowels. See Casali 2001 for a recent report on a survey of over 100 African languages with all three kinds of [±ATR] contrasts in nonlow vowels.

[16] Low vowels appear to be universally [−ATR], and thus universally harmonically unpaired with respect to [±ATR] harmony (Goad 1993, Casali 2001; *cf.* Bakovic 2000). Apparent counterexamples include Wolof and Diola Fogny (Northern Atlantic-Congo; Ka 1988, Sapir 1965) and Kalenjin (Southern Nilotic; Tucker 1964, Hall et al. 1974), but these languages pair the low [−ATR] vowel *a* with the mid [+ATR] vowel *ə*, achieving what appears to be harmonic pairing via what I call *re-pairing*, described in the text further below.

Akan has what could be described as a [+ATR] low vowel, but it does not behave as such with respect to the vowel harmony process and its distribution is restricted in a way that suggests it is a low-level phonetic variant of the low vowel, as argued by Clements (1981).

(19)   Harmonic pairing in Tangale, Yoruba, and Akan (harmonic pairs are boxed)

    a. Tangale   b. Yoruba   c. Akan

Tangale	Yoruba	Akan
i u	i u	i u
ɪ ʊ		ɪ ʊ
e o	e o	e o
ɛ ɔ	ɛ ɔ	ɛ ɔ
a	a	a
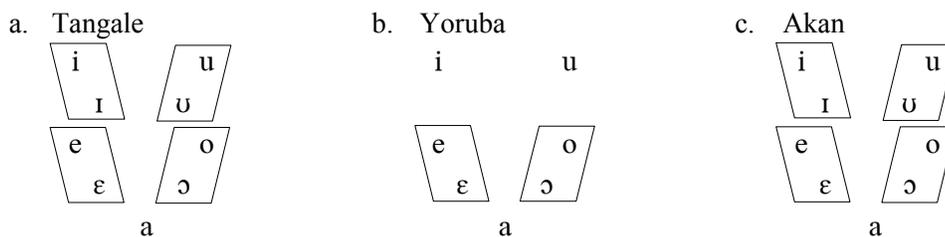
       A harmonically unpaired vowel exhibits one of a small set of different behaviors under the influ-ence of vowel harmony in different languages. The behavior of immediate interest here is *opacity*. An opaque vowel blocks the propagation of root-outward vowel harmony when the opaque vowel differs in terms of the harmonic feature from the next nonalternating vowel closer to the root (ultimately, the closest vowel in the root itself). The blocking behavior follows the stem precedence generalization in (17): an opaque affix vowel initiates its own harmonic domain on further alternating affix vowels, but does not reverse the root-outward 'direction' of harmony.

       Another type of behavior exhibited by harmonically unpaired vowels in some languages is *trans-parency* (see the text surrounding footnote 13 above).[17] Yet a third type of behavior exhibited by har-monically unpaired vowels is what I refer to in other work as *re-pairing* (Bakovic 2000, 2001ab, in prep.), whereby a technically unpaired vowel *x* harmonically alternates with a vowel that differs from *x* in terms of *both* the harmonic feature *and* some other feature(s). Because re-pairing results in an alternating vowel, it is irrelevant to the stem precedence generalization.

4.2   Stem precedence: a real example

Representative examples from Yoruba of the stem precedence generalization with respect to opacity are given in (20) below. Recall my assumption (following the references cited in footnote 7) that Yoruba morphology is strictly prefixational, and thus that the root morpheme is on the far right. Opaque vowels are italicized for ease of identification.

(20)   Opacity in Yoruba …

    a.   … with [–ATR] low vowels (*a*)   b.   … with [+ATR] high vowels (*i,u*)

      i. /*A* + jE+ √re/ → [*a*jere]   i. /*I* + kE + √rɛ/ → [*i*kɛrɛ]
           'name of a Yoruba town'   'name of a Yoruba town'
      cf. /*A* + bE + √rɛ/ → [*ab*ɛrɛ]   *cf.* /*I* + jE + √re/ → [*i*jere]
             'needle/pin'   'a kind of seed'

      ii. /E + r*A* + √kpo/ → [ɛr*a*kpo]   ii. /O + k*I* + √gbɛ/ → [ok*i*gbɛ]
           'type of plant'   'magical drug'
                       cf. /O + j*I* + √bo/ → [oj*i*bo]
                              'any European'

       In each pair of examples in (20), a form in which an opaque affix vowel blocks the propagation of harmony from a differently-specified root vowel is compared with a form in which there is no blocking because the two vowels happen to agree in terms of the harmonic feature. (There is no comparison form

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[17] The link between transparency and harmonic pairing was originally made at least as early as Fudge 1967, and was later reinforced and extended to opacity in Kiparsky 1981.

for the form in (a.ii.) due to an accidental lexical gap in Yoruba.) In the (i) examples in each set, the opaque vowel is separated from the root vowel by an affix vowel in the middle; this middle vowel agrees with the root vowel, in accordance with the stem precedence generalization. In the (ii) examples, the opaque vowel itself is in the middle; the other affix vowel, now further from the root than the opaque vowel, agrees with the opaque vowel — again, in accordance with the stem precedence generalization.

4.3   Stem identity / stem-affixed form faithfulness

Pretheoretically, the reason for stem precedence is not at all obvious; either way, one ends up with a disharmonic form, because an opaque vowel inevitably disagrees with some vowel closer to the root. Under the stem identity analysis of root-outward vowel harmony, stem precedence follows automatically: by the definition of stem identity in (11)b, vowel harmony can only proceed from the root outward.

  Consider how opacity and stem precedence are accounted for under the stem-affixed form faithfulness analysis introduced in §3. When a vowel is not harmonically paired in a language, it is commonly understood in OT to be due to the relatively high rank of a feature co-occurrence constraint involving the harmonic feature. For example, the low vowel *a* is harmonically unpaired in Tangale, Yoruba, and Akan due to the constraint in (21)a, and the high vowels *i,u* are harmonically unpaired in Yoruba due to the constraint in (21)b. Both constraints crucially involve (different values of) the harmonic feature [±ATR]:[18]

  (21)   Feature co-occurrence constraints responsible for [±ATR] opacity

         a.   *[+low, +ATR]
                An output segment is not simultaneously specified as [+low] and [+ATR].

         b.   *[+high, −ATR]
                An output segment is not simultaneously specified as [+high] and [−ATR].

  By ranking both of these constraints together with SA-IDENT[±ATR] above AGREE[±ATR] — which must itself be ranked above IO-IDENT[±ATR] in order to have harmony in the first place, as discussed in §3 — we can account for the opacity of high and low vowels in Yoruba. To make the more general point about root-outward opacity, I substitute [±*hf*] for [±ATR] in the tableau in (22) below. A second, opaque affix vowel represented as 'V_{afx}^{opq}' has been added to the stem of affixation already derived in tableau (15). I also substitute '$V_{afx}^{opq}{\neq}[\alpha hf]$' for the feature co-occurrence constraints responsible for [±ATR] opacity in (21); apart from serving to minimize the clutter of specifying multiple features in the representations, this schematic constraint is appropriate to make the point that while opacity is often due to a lack of harmonic pairing, it is also sometimes due to the lexical exceptionality of some morpheme or vowel. Whatever the reason for V_{afx}^{opq}'s opacity, $V_{afx}^{opq}{\neq}[\alpha hf]$ covers it.

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[18] On the articulatory and perceptual bases of these constraints, see Archangeli & Pulleyblank 1994 and references therein (especially Pike 1967, Stewart 1967, Ladefoged 1968, Halle & Stevens 1969, and Lindau 1978, 1979).

(22) Root-outward opacity

Input: $[\,[\,V_{stem}\,]\,V_{afx}\,] + V_{afx}^{opq}$
        $[\alpha hf]\!\to\,\to$

Candidates		$V_{afx}^{opq}\!\neq\![\alpha hf]$	SA-IDENT[$\pm hf$]	AGREE[$\pm hf$]
a.	$[\,[\,[\,V_{stem}\,]\,V_{afx}\,]\,V_{afx}^{opq}\,]$ $[\alpha hf]\!\to\,\to\,\to\,\to$	*!		
b. ☞	$[\,[\,[\,V_{stem}\,]\,V_{afx}\,]\,V_{afx}^{opq}\,]$ $[\alpha hf]\!\to\,\to\;\;[-\alpha hf]$			*
c.	$[\,[\,[\,V_{stem}\,]\,V_{afx}\,]\,V_{afx}^{opq}\,]$ $[\alpha hf]\;\;\leftarrow\,\leftarrow[-\alpha hf]$		*!	*
d.	$[\,[\,[\,V_{stem}\,]\,V_{afx}\,]\,V_{afx}^{opq}\,]$ $\leftarrow\,\leftarrow\,\leftarrow\,\leftarrow[-\alpha hf]$		*!*	

IO-IDENT[$\pm hf$] is left out of this tableau due to its bottom-ranked extraneousness. First of all, the underlying harmonic feature value of V_{afx}^{opq} is irrelevant; given the undominated rank of $V_{afx}^{opq}\!\neq\![\alpha hf]$, this vowel is bound to surface as [$-\alpha hf$]. Secondly, the underlying harmonic feature values of the other two vowels could be the same as they were in the input for tableau (15), but what matters here is the shared harmonic feature value in the optimal form that was derived in that tableau, with the value of the affix vowel changed to agree with the value of stem vowel.

The first candidate in (22)a, in which V_{afx}^{opq} is made to agree with the [αhf] harmonic feature value of the stem, is ruled out by the undominated constraint responsible for opacity, $V_{afx}^{opq}\!\neq\![\alpha hf]$. The competition thus narrows down to candidate (22)b, in which V_{afx}^{opq} surfaces disharmonically as [$-\alpha hf$], and candidates (22)c and (22)d, in which one or both stem vowels are made to agree with the [$-\alpha hf$] harmonic feature value of V_{afx}^{opq}. These latter two candidates both fatally violate the undominated constraint responsible for stem identity, SA-IDENT[$\pm hf$]; the former candidate, though disharmonic (i.e., in violation of low-ranked AGREE[$\pm hf$]), is thus optimal.

Note that this result generalizes to account for the grammaticality of the longer schematic example of root-outward opacity in (16) because the stem vowel in the tableau could just as well be one in a series of vowels in a morphologically more complex form, the one that is adjacent to the alternating affix vowel. The stem precedence generalization is thus accounted for. Because the stem-affixed form faithfulness constraint for the harmonic feature is undominated, the alternating affix vowel has already been determined to agree with the adjacent stem vowel by the time the opaque affix vowel comes along. Even though the alternating affix vowel might be underlyingly specified for the surface harmonic feature value of the opaque affix vowel, stem identity correctly ensures that this alternating affix vowel is made to agree with the adjacent stem vowel on the surface.

The alternative analyses under consideration in this article must independently stipulate stem precedence. More importantly, attempts to do so are often unsuccessful at capturing the right generalization. In the remainder of this section, I summarize various actual attempts in the literature to grapple with the stem precedence generalization in underspecification and/or directionality analyses of root-outward vowel harmony. For expository purposes, these summaries necessarily abstract away from formal detail that is technically irrelevant to the matters at hand. It should be noted from the outset, however, that each of these proposals is evaluated entirely on the grounds of how well it accounts for the stem precedence generalization, which I take to be a linguistically significant generalization that — as just demonstrated — the stem identity analysis captures parsimoniously.

4.4   Alternatives I: Underspecification

Typically, only alternating vowels are ever claimed to be underspecified for the purposes of vowel harmony. Both root vowels and opaque vowels must thus be specified for the harmonic feature in order to explain why neither alternates; or, more to the point, why neither alternates to agree with the other. The problem, then, is how the specification of a root vowel prevails over the opposite specification of an opaque vowel in determining the harmonic fate of any vowel(s) between them. Various kinds of solutions to this problem have been offered in the literature.

4.4.1   Underspecification and activity

To account for stem precedence in her analysis of Igbo, another Benue-Congo language (Green & Igwe 1963, Zsiga 1997), Ringen (1975 [1988]:122*ff*) proposes that only one value of the harmonic feature is referenced by the vowel harmony process — namely, *not* the value of the opaque vowel. In Igbo, all opaque vowels have the same value of the harmonic feature, [–ATR].[19] So, by Ringen's analysis, only [+ATR] is referenced by the vowel harmony process. If there is a root vowel underlyingly specified as [+ATR], this feature value is copied (or, equivalently, spread) onto any neighboring underspecified vowels. Stem precedence is thus the result of the feature value of the opaque vowel being 'inactive' — not acted upon by the harmony process. A vowel closer to the root than a differently-specified opaque vowel therefore cannot possibly be made to agree with the opaque vowel.

There are several issues that arise under Ringen's account. The first of these is a relatively minor one but still worth noting here. Despite the ultimate reliance on underspecification, Ringen's proposed harmony rules are still stated directionally. Two rules are thus necessary for bidirectional harmony, "which could be collapsed by a convention such as Bach's (1968) neighborhood convention" (Ringen 1975 [1988]:123). Because this redundancy has more to do with the strictly linear representations and rule mechanisms at Ringen's disposal in 1975 than with anything else, I proceed with the understanding that an equivalent analysis without directional rules is possible, if only in principle.

A second issue is much more significant: how are vowels *further* from the root than an opaque vowel eventually specified with the same value of the harmonic feature as that opaque vowel? Under Ringen's account, only strings of vowels that agree in terms of the 'active' value of the harmonic feature actually do so due to the vowel harmony process itself. Strings of vowels that agree in terms of the 'inactive' value must only agree by accident, as it were, due to a subsequent context-free process that fills that value in on vowels otherwise still underspecified after the application of harmony.[20] Thus, not all aspects of the stem precedence generalization are accounted for by the same analytical mechanism: a vowel closer to the root than an opaque vowel agrees with the root due to the harmony process, while a vowel further from the root than the opaque vowel agrees with the opaque vowel due to the context-free process.

The third issue raised by Ringen's analysis is the most substantive. In a language with two different kinds of opaque vowels, each specified for different values of the harmonic feature, which harmonic feature value is referenced by the harmony process is undefined. Recall from (19)b that the harmonic feature value of an opaque vowel in Yoruba depends on whether it is low or high: low vowels are

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[19] Opaque vowels in Igbo are all morphologically idiosyncratic; the [–ATR] low vowel *a* is harmonically unpaired, but rather than being opaque, it is re-paired with the [+ATR] mid vowel *e* under harmony.

Incidentally — but irrelevantly in the following text — Igbo has both prefixes and suffixes and therefore bidirectional vowel harmony, like Akan.

[20] This type of account has become fairly common subsequent to Ringen's work, especially in the analysis of dominant-recessive harmony processes. In fact, another argument Ringen makes in favor of her formulation of the vowel harmony process in Igbo is that it is the same formulation needed for the description of dominant-recessive vowel harmony in Diola Fogny (an argument also made by Anderson (1980); see §4.4.4). Under this account, the difference between root-outward and dominant-recessive harmony boils down to whether only roots or both roots and affixes can be underlyingly specified for the value of the harmonic feature that is referenced by vowel harmony.

inalterably [−ATR], as shown by the examples in (20)a, and high vowels are inalterably [+ATR], as shown in (20)b. Ringen's account does not straightforwardly extend to a language like this. If the vowel harmony process in Yoruba only acts upon [+ATR], then stem precedence with respect to high vowel opacity is unaccounted for: [+ATR] could in principle be copied or spread from an opaque high vowel onto a vowel closer to the root. If vowel harmony only acts upon [−ATR], then stem precedence with respect to low vowel opacity is similarly unaccounted for, *mutatis mutandis*. In short, Ringen's solution can at best only work for one half of the opacity facts in a language like Yoruba; it cannot be made to work for both.

4.4.2   Underspecification, activity, and directionality

Readers familiar with Archangeli & Pulleyblank's (1989, 1994) excellent treatment of Yoruba may take exception with this last judgment on Ringen's account. These authors put forth and defend the claim that only one value of the harmonic feature, [−ATR], is active in Yoruba vowel harmony. Within the context of the specific theoretical assumptions that Archangeli & Pulleyblank were laboring under (e.g., radical underspecification), their analysis has much to recommend it. However, this analysis also misses the *stem precedence generalization* — though somewhat differently from the ways in which Ringen's analysis misses it, as I explain in detail in what follows.

To account for stem precedence in the case of opaque low vowels, the 'active' harmonic feature value [−ATR] must spread *only leftward* — that is, directionally, from right to left — both from final (here, root) vowels and from low vowels.[21] This ensures that an alternating mid vowel closer to the root will always reliably agree with the root vowel, either by right-to-left spreading of [−ATR] or by a context-free default rule inserting [+ATR] on both the root and the mid vowel. Alternating mid vowels further from the root always reliably agree with the opaque low vowel by right-to-left spreading of [−ATR].

In the case of opaque high vowels, stem precedence results from the fact that high vowels cannot be associated with (or skipped by) active [−ATR].[22] Being inactive (or not present in the representation), [+ATR] does not spread from high vowels and so there is no danger that a vowel closer to the root will be made to agree with a high vowel; as before, it will always reliably agree with the root vowel. Alternating mid vowels further from the root then surface as [+ATR] not due to harmony with the opaque high vowel but due to the context-free default process.

Thus, the stem precedence generalization is not captured in a unified manner under Archangeli & Pulleyblank's analysis, not only because [−ATR] harmony and [+ATR] default are separate processes — similar to Ringen's two-pronged analysis of Igbo — but also because low vowels and high vowels must be treated differently by these two processes. The relevant cases are diagrammed schematically in (23) as a visual aid to this argument.[23] Solid lines are links to instances of either underlying [−ATR] specifications on final (root) vowels or redundant [−ATR] specifications on low vowels, both associated by rules prior to the harmony and default rules of immediate interest. Dotted lines linking [−ATR] specifications represent the result of harmony (i.e., [−ATR] spreading) and those linking [+ATR] specifications are supplied by the default rule.

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[21] Low vowels are uniformly specified as [−ATR] at a derivational point prior to leftward [−ATR] spreading. In Archangeli & Pulleyblank 1989:179, this is achieved via a "[−ATR] Redundancy Rule" targeting low vowels. In Archangeli & Pulleyblank 1994:240-241, the same result is achieved by a more general "[−ATR] Insertion" rule that is restricted to low vowels by the independent grounding condition RTR/LO ('if [−ATR], then [+low]').

[22] In Archangeli & Pulleyblank 1989:183, this is achieved via the "Yoruba High:ATR Cooccurrence Constraint" stipulating that [−ATR] may only be linked to [−high] vowels. In Archangeli & Pulleyblank 1994:241-242, the same result is achieved by subjecting the rules associating and spreading [−ATR] to the independent grounding condition RTR/HI ('if [−ATR], then [−high]').

[23] Archangeli & Pulleyblank do not assume that all polysyllabic forms are morphologically complex (see also footnote 24 below). The morphological representations here thus reflect my own assumptions about strict prefixation in Yoruba, following the work cited in footnote 7 above.

(23)   Yoruba root-outward opacity (Archangeli & Pulleyblank 1989, 1994), schematized …

a.   … with [−ATR] low vowels   b.   … with [+ATR] high vowels

i. $[\, V_{pfx}^{lo} \, [\, V_{pfx}^{mid} \, [\, \sqrt{V} \,] \,] \,]$ i. $[\, V_{pfx}^{hi} \, [\, V_{pfx}^{mid} \, [\, \sqrt{V} \,] \,] \,]$

         [−ATR]   [+ATR]   [+ATR]   [−ATR]

ii. $[\, V_{pfx}^{mid} \, [\, V_{pfx}^{lo} \, [\, \sqrt{V} \,] \,] \,]$ ii. $[\, V_{pfx}^{mid} \, [\, V_{pfx}^{hi} \, [\, \sqrt{V} \,] \,] \,]$

         [−ATR]   [+ATR]   [+ATR]   [−ATR]

Because low vowels are specified for the active value of the harmonic feature, [−ATR], they must be explicitly prevented from spreading that value onto a vowel closer to the root, whether that vowel is another prefix vowel (as in (23)a.i) or the root vowel itself (as in (23)a.ii) — thus the need for right-to-left directionality of the harmony process. The default, inactive harmonic feature value [+ATR] is then filled in on the remaining unaffected vowels in each case.

High vowels, on the other hand, are specified for the inactive [+ATR] value of the harmonic feature (eventually, by the default rule). Thus, they do not threaten to spread anything to a mid vowel closer to the root, which is then free to harmonize with the [−ATR] root vowel (as in (23)b.i). Finally, because high vowels block [−ATR] harmony from the root, a mid vowel further from the root will also correctly be specified with the default [+ATR] value (as in (23)b.ii).

This critique of Archangeli & Pulleyblank's analysis rests again on the assumption made here that stem precedence, as seen through the behavior of opaque vowels, is a generalization that requires a unified account. To be fair, however, Archangeli & Pulleyblank's motivation for positing that [−ATR] is the only active harmonic feature value in Yoruba must be independently evaluated. The primary argument comes from a difference in behavior between high and low vowels in final (root) position. Low vowels in this position, as everywhere, are [−ATR] and require that preceding alternating mid vowels also be [−ATR]. High vowels in this position — again, as everywhere — are [+ATR], but appear *not* to require that preceding alternating mid vowels be [+ATR]. This difference is accounted for by the fact that active [−ATR] spreads from final low vowels but inactive [+ATR] does not spread from final high vowels.[24]

Two interesting pieces of evidence undermine this argument, however. One is the fact that other dialects of Yoruba — Archangeli & Pulleyblank's analysis is of Standard Yoruba — *do* require that preceding (prefix) mid vowels agree with final high vowels (as well as with final low vowels — e.g., the Ijesa dialect; Awobuluyi 1967, Fresco 1970). Ascribing this separable fact of Standard Yoruba to the inactivity of [+ATR] severely impacts the analysis of vowel harmony, forcing it to differ more from the analysis of vowel harmony in Ijesa than the surface differences between these dialects would suggest.

The other piece of evidence comes from the consistent distribution of [−ATR] and [+ATR] mid prefix vowels before high vowel roots in Standard Yoruba. High vowel roots come in two varieties: those that consistently take [+ATR] mid vowel prefixes ($\sqrt{ru}$ 'to disrupt', $e + \sqrt{ru}$ 'dishonesty') and those that consistently take [−ATR] mid vowel prefixes ($\sqrt{mu}$ 'to drink', $\mathrm{o} + \sqrt{mu}$ 'drinker', $\varepsilon + \sqrt{mu}$ 'palm-wine'). To adequately describe this regularity, some consistent underlying distinction between these two types of high vowel roots must be posited. Archangeli & Pulleyblank represent those high vowel roots that take [−ATR] prefixes as underlyingly affiliated with an unlinked [−ATR] specification and those that take [+ATR] prefixes as underlyingly underspecified. In the former case, [−ATR] is unable to actually as-

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[24] The fact that high and low vowels behave the same way (opaquely) in nonfinal position not only requires the divided analysis summarized in the text above, but also requires that root morphemes be limited to at most one harmonic feature specification (in addition to the underspecification of prefix vowels). This is because Archangeli & Pulleyblank take the virtual lack of synchronic evidence for the morphological complexity of polysyllables in Yoruba at face value; as noted in footnote 7, I trade this aspect of their analysis in for a more aggressive morphological analysis of Yoruba words. (See §5.3 for some further discussion of this issue.)

sociate with the high vowel in the root (see footnote 22) and so associates only with the mid vowel in the prefix. In the latter case, both root and prefix vowels are eventually associated with [+ATR] by default.

So, the real difference between final (root) high and low vowels is that, before the application of harmony, the low vowels are systematically [–ATR] while the high vowels are ambiguously, but consistently for each root, [–ATR] or *not* [–ATR]. Now, there is very little if any difference between this and saying that the '*not* [–ATR]' high vowels are in fact [+ATR], and that [+ATR] spreads from those high vowel roots that happen to be specified as [+ATR]. Under this alternative analysis, both harmonic feature values are underlyingly specified and active. What is different about Standard Yoruba is that some high root vowels are underlyingly [–ATR] even though they don't themselves surface as such; the evidence for their counterspecification comes from their harmonic behavior. This is entirely parallel to analyses of similar cases in Hungarian (Vago 1976) and Yawelmani (Kuroda 1967),[25] and pursuing this type of analysis (see Bakovic 2000:151*ff* for a specific proposal) opens up the desirable possibility of capturing the stem precedence generalization that unfortunately eludes Archangeli & Pulleyblank's account.

4.4.3   Underspecification and priority of association

The solution to stem precedence proposed by Clements (1976 [1980]:61*ff*) — with representative data from both Akan and Igbo — avoids the pitfalls of both of the previous solutions by relying instead on a representational difference between the harmonic feature specifications of root vowels and those of opaque vowels. Clements argues that while the harmonic feature value of an opaque vowel must be underlyingly 'bound' (i.e., autosegmentally linked) to that vowel, the harmonic feature value of a (nonopaque) root vowel is unbound. This leads to a "further clause to the well-formedness condition" (Clements 1976 [1980]:62, (32); see also Clements 1977:118, fn. 2):

(24)   Priority Clause A
        Unbound segments are associated before bound segments.

The term 'segments' in this clause refers to harmonic autosegments; that is, to harmonic feature specifications. The unbound specification of a root vowel takes associative precedence over the bound specification of an opaque vowel, meaning that the root vowel's specification associates both with the root vowel as well as with any other vowels closer to the root than the opaque vowel. Only then is the bound specification of the opaque vowel free to associate, by which time the only unspecified vowels left are any that there may be further from the root (because the opaque vowel's association line may not be crossed). This accounts for the fact that alternating vowels closer to the root than an opaque vowel agree with the nearest root vowel while those further from the root agree with the opaque vowel.

Taking Clements' discussion surrounding his proposal of Priority Clause A at face value, the stem precedence generalization is a welcome but in fact secondary consequence of the clause. Its primary motivation is the clearly related situation in which a syllable headed by a root vowel with an unbound harmonic feature specification is *immediately adjacent* to a syllable headed by an opaque vowel with a bound specification of the opposite value; that is, with no syllable in between. (Clements focuses on an Akan example in which these vowels are adjacent within a disharmonic root, but the same point can be made with examples in which the opaque vowel syllable is in an affix immediately adjacent to the root.) The question is why the bound specification of the opaque vowel does not spread to the (other) root vowel; Clements' answer is Priority Clause A.

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[25] In Hungarian, some roots with harmonically unpaired nonlow [–back] vowels unexpectedly trigger [+back] harmony, suggesting that they are underlyingly [+back]. For recent discussion of Hungarian, see Ringen & Vago 1995, 1998, Lewis 2002, and Reiss 2003. In Yawelmani, [±round] harmony is [±high]-dependent, but some roots with long [–high] vowels unexpectedly affect [+high] affix vowels, suggesting that the long root vowels are underlyingly [+high]. For recent discussion of Yawelmani, see Archangeli & Suzuki 1997 and McCarthy 1999.

Although it avoids the problems noted with the solutions discussed further above, there is a significant empirical problem with Clements' solution. The problem was originally discussed by Anderson (1980:22*ff*), and again the argument relies on facts from a language with two different kinds of opaque vowels. The relevant data in this case, however, involve examples in which both kinds of opaque vowel occur *within a single form*, separated by at least one syllable. I follow Anderson in discussing his examples from Turkish, since Turkish words get long enough to make the proper argument.[26]

Turkish is exclusively suffixing (like Tangale) and exhibits both backness and rounding harmony, but the relevant data only concern the rounding harmonic pattern. There are a few kinds of vowels that are opaque to rounding harmony. One kind is the set of [–high] vowels, which are harmonically unpaired in noninitial syllables and thereby opaque: there is noninitial [–high, –round] *a,e* but no [–high, +round] *o,ö*.[27] Other kinds of opaque vowels are certain cases of [+high, +round] *u* due to "'labial attraction', by which, if the first vowel of the word is *a*, the second [+high], and the intervening consonantism includes at least one labial, the second vowel is [+round]" (Anderson 1980:23).[28] A form with both of these kinds of opaque vowel will necessarily be disharmonic, because neither vowel will alternate to agree with the other. The question is, what happens to an alternating vowel potentially lying between the two opaque vowels? The answer is that stem precedence still holds: the opaque vowel that is closer to the root determines the harmonic feature specification of any and all vowels in between.

The Turkish example in (25) demonstrates the relevant situation. The opaque vowel closer to the root (in this case, *in* the root) is a [+high, +round] *u* due to labial attraction, while the opaque vowel further from the root is a [–high, –round] *E* — potentially *a* or *e*, independently determined by backness harmony — which is harmonically unpaired with respect to rounding in noninitial syllables. Note that the alternating high vowels in between surface as [+round], in agreement with the *u* closer to the root.

(25)   Turkish stem precedence between opaque vowels (Anderson 1980:24)

/√havr*u*z + InIz + d*E*/   →   [hav*ruzunuz*da]
chamberpot + 2pl.poss. + too   'your (pl.) chamberpot, too'

Now under Clements' own assumptions, both opaque vowels would be specified with bound instances of the harmonic feature, and Priority Clause A in (24) would have nothing to say about the harmonic fate of any vowel(s) between them. However, Anderson (1980) does not cite Clements 1976 [1980] but rather Clements 1977, in which only Priority Clause A is discussed, but Clements (1976 [1980]:72) proposes yet another clause to the well-formedness condition to account for "a more general principle of root control". The principle is informally stated as follows: "[a]ll nonopaque vowels in a domain agree with the closest occurrence of a harmony-characterizing feature P such that if the domain contains prefixes (resp., suffixes), P is not to its left (resp., right)." Priority Clause B is reformulated "in such a way that it does not require separate reference to prefixes and suffixes, but only to the category 'root'". (The formulation in (26) is from Clements 1976 [1980]:72, (64).)

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[26] Yoruba unfortunately does not provide the requisite forms for the argument: words are never longer than three syllables, meaning that one of the opaque vowels is also the root vowel. The harmonic behavior of such words is by now predicted and has already been discussed at length.

[27] The fact that [–high] vowels in Turkish are harmonically unpaired only in noninitial syllables is specifically addressed in §5.2 below.

[28] An anonymous reviewer points out that "[l]abial attraction does not appear to be a real generalization about Turkish", citing Clements & Sezer 1982. This does not affect the argument being made here; the relevant [+high, +round] vowels must be treated as opaque under any account, regardless of their ultimate reason for being.

(26)   Priority Clause B (Root Control)

Given the configuration:

$$X_1 \quad V \quad \sigma \quad V \quad X_2$$
$$\quad\quad | \quad\quad\quad | \quad\quad$$
$$\quad\quad P_1 \quad\quad\quad P_2 \quad\quad$$

all vowels occurring in the domain σ are bound to that P_j such that $X_j = \dots$ [+root] $\dots$

Now note that Priority Clauses A (24) and B (26) clearly express two sides of the very same generalization, that stem specifications take precedence over affix specifications, and so should properly be collapsed into one.[29] But the overarching problem for Clements' solution remains that one or both of these Priority Clauses must be stipulated in the first place. This is in addition to underspecification, which is itself a stipulation that roots but not affixes are equipped with (unbound) harmonic feature specifications underlyingly (modulo opaque vowels and their (bound) harmonic feature specifications, of course). Both devices make the same critical distinction between roots and affixes, an undesirable duplication of effort that is necessary simply in order to account for the stem precedence generalization.

It is important to consider the independent evidence that Clements (1976 [1980]) offers in favor of the distinction made by Priority Clause A between 'bound' and 'unbound' autosegments. The initial argument that harmonic feature specifications are underlying unbound to (nonopaque) root vowels is presented as a variant of the classic 'simplicity metric' in generative phonology (beginning with Chomsky & Halle 1968), the idea being that a grammar is penalized for the degree to which its lexical representations are specified with information that is predictable by rule or convention. Because association between the segmental and harmonic feature tiers is guaranteed by Goldsmith's (1976 [1979]) well-formedness condition, the existence of some association lines — e.g., those between root vowels and their harmonic feature specifications — is predictable and should therefore not be specified. Clements (1976 [1980]:59) writes:

> "Notice that the one formal entity that the present theory [i.e., the theory of autosegmental phonology — EB] adds to phonological representation is the association line. In evaluating the relative complexity of representations, we shall assume that *all things being equal,* the representation with the smallest number of entities will be selected." [Emphasis added — EB.]

Emphasis is added to the "all things being equal" part of this quotation to highlight a circularity in Clements' overall argument. In order for Priority Clause A to work as intended, (nonopaque) root vowels must crucially not be lexically associated with a harmonic feature value. What this means is that two grammars, one with root vowels lexically associated with harmonic feature values and one without, will produce empirically distinct languages. The problem, then, is that all things are in fact not equal. Halle (1979:331) is particularly explicit on the matter that the simplicity metric may only be invoked when deciding among empirically equivalent grammatical statements, and also deserves quotation:

> "[S]implicity considerations are relevant only in a restricted class of cases — i.e., in cases [...] where the same theory admits two or more alternative formulations that cover the exact same body of facts. [...] The fact that simplicity considerations are irrelevant in [other] cases does not

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[29] This could presumably be done by reducing both clauses to Priority Clause B, and making the association lines that are obligatory in the diagram in (26) optional instead. Note that this particular reduction would make two different predictions than those made by having both Priority Clauses A and B as they are stated by Clements and in the text. One is that a bound specification closer to the root will take priority over an unbound specification further from the root, contrary to Priority Clause A. The other is that of two unbound specifications, the one closer to the root will take priority (unless the optionality of one association line were made contingent on the optionality of the other), a situation about which neither of the Priority Clauses says anything. Interestingly, both of these situations depend on the possibility of unbound specifications in an affix, which Clements rejects: affix vowels are either unspecified for the harmonic feature (alternating) or are bound to a specified harmonic feature value (opaque).

...

mean that there are no rational ways of choosing between alternative theories but only that this
choice has to be made on grounds other than simplicity."

In sum, Clements can invoke his simplicity metric only insofar as there is no crucial distinction between
bound and unbound autosegments — that is, only insofar as these two kinds of representation "cover the
exact same body of facts." But Priority Clause A *does* crucially distinguish bound from unbound auto-
segments, and so the simplicity metric is irrelevant. As far as I can tell, there is no additional evidence
presented in Clements' work supporting the distinction between bound and unbound autosegments.[30]

4.4.4   Summary

In this section I discussed three proposals in the literature to account for the stem precedence generaliza-
tion under the general underspecification rubric. I hope to have shown that each of these proposals faces
serious difficulties when confronted with different aspects of this generalization, and each ends up having
to rely on additional mechanisms (most notably feature value activity, directionality, and priority of asso-
ciation) that either duplicate the basic mechanism of underspecification or else further complicate the
situation by introducing new empirical problems. None of these accounts is able to achieve, even with
difficulty, what the stem identity account achieves very simply: the simple generalization that an alter-
nating affix vowel always agrees with the neighboring vowel in the stem to which the affix is attached.

4.5   Alternatives II: Directionality

The only author that I know of who explicitly addresses the issue of stem precedence and offers a solution
in terms of directionality is Anderson (1980), who argues that if vowel harmony in Turkish — a language
with only suffixes, as noted above — does in fact operate directionally, from left to right, it follows that a
vowel closer to the root always takes precedence over an opaque vowel in determining the fate of a vowel
between them (Anderson 1980:22*ff*). This result holds whether the vowel closer to the root is a vowel in
the root itself or another opaque vowel, thus avoiding the specific problem noted in the preceding subsec-
tion for Clements' Priority Clause A. Anderson's solution extends to strictly prefixing languages like
Yoruba, in which vowel harmony must simply operate in the opposite direction (i.e., from right to left).
      For languages like Akan and Igbo, with both prefixes and suffixes and bidirectional root-outward
harmony, Anderson (1980:38*ff*) adopts Ringen's underspecification analysis, discussed in §4.4.1. By this
point in his paper, however, Anderson is no longer explicitly discussing stem precedence; it is therefore
not clear whether he adopts this analysis for anything other than the wholly independent reason noted in
footnote 20: that bidirectional root-outward harmony can be modelled after (necessarily bidirectional)
dominant-recessive harmony. Regardless of his motivation, Anderson effectively has two very different
accounts — directionality for unidirectional harmony, underspecification for bidirectional harmony — of
what I have argued should properly be a unitary descriptive generalization: stem precedence.
      Because Anderson adopts Ringen's solution for languages with bidirectional harmony, the prob-
lems already noted for Ringen's solution are also problems for Anderson's in just those cases. First, re-
call that in Ringen's solution, harmony is divided into a copying/spreading process referring only to the
active harmonic feature value and a default fill-in process referring only to the inactive value. This means
that vowels closer to the root than an opaque vowel agree with the root due to copying/spreading but
vowels further from the root agree with the opaque vowel due to the default process. Second, recall also
that Ringen's solution crucially relies on a serendipitous state of affairs in which the active value of the
harmonic feature is the opposite of the harmonic feature value of the opaque vowels of the language. In-

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[30] Based on their detailed study of disharmonic roots in Turkish, Clements & Sezer (1982:227*ff*) conclude that all
root vowels in Turkish are opaque; that is, underlyingly associated with some specified value of the harmonic fea-
ture. This effectively makes the distinction between bound and unbound autosegments irrelevant for the analysis of
anything, stem precedence or otherwise.

sofar as this state of affairs cannot be guaranteed in principle, the stem precedence generalization is to be regarded as no more than an interesting accident under this account.

The third argument that was levelled against Ringen's solution, based on the two kinds of opaque vowel in Yoruba, could technically be countered by Anderson. The opaque behavior of both high and low vowels in Yoruba is accounted for by the fact that harmony is unidirectional; underspecification is unnecessary and the harmony process can thus safely refer to both values of the harmonic feature. This counterargument crucially depends on the fact that Yoruba only has prefixes and thus that harmony is unidirectional; what we should be on the lookout for, then, is a language like Yoruba but with both prefixes and suffixes (i.e., with bidirectional root-outward harmony). If both high and low vowels are opaque as they are in Yoruba, then neither part of Anderson's solution will suffice to account for this fact.

All of these arguments are all the more pointed for Anderson's solution precisely because they only apply to languages with bidirectional harmony, languages with unidirectional harmony being amenable to analyses in terms of directionality rather than underspecification. This division of analytical labor raises an important substantive question: what is the basis for the correlation between the type of harmony process (unidirectional, bidirectional) and the device used for its analysis (directionality, underspecification)? The answer to this question can be no more direct than that proferred by the proposed stem identity account: languages with unidirectional root-outward harmony either only have prefixes or only have suffixes, while languages with bidirectional root-outward harmony have both.

Bidirectional root-outward harmony is the real Achilles' Heel for directionality, simply because it is not amenable to a clean account in directional terms. The root must be independently identified both as the harmony source and as the reference point for the continued root-outward behavior of opaque vowels. Under the proposed stem identity analysis, by contrast, there is no need for an independent analytical distinction between bidirectional and unidirectional root-outward harmony, nor between left-to-right and right-to-left harmony in the latter class of cases. Stem identity capitalizes on the redundancy between morphological structure and apparent directionality by appealing directly to morphological structure, thus achieving a desirably parsimonious account of stem precedence in all cases.

4.6   Summary

Stem precedence is a robust, linguistically significant generalization for which a unified analysis is necessary. I have argued in this section that of the three analytical approaches to root-outward vowel harmony considered in this article, only the proposed stem identity approach provides for a direct and unified analysis of the stem precedence generalization by directly appealing to the morphological structure of words, requiring that harmony between a stem vowel and an affix vowel in adjacent syllables operate in such a way that the process does not affect the stem vowel. Attempts to account for stem precedence in the literature under the alternative underspecification and directionality approaches invariably lead to fragmented or inadequate analyses of stem precedence.

As cautiously noted in §2.4, however, the arguments provided here do not by themselves seal the coffins of directionality or underspecification, not even as these mechanisms apply to (other types of) vowel harmony. My goal has been merely to demonstrate that stem identity is a superior alternative in the analysis of root-outward vowel harmony. I am encouraged, however, by the concensus that seems to have been arrived at in the current literature that the excessive descriptive power — and consequent explanatory weakness — of directionality and underspecification must be reined in and, insofar as is possible, delegated to other, independently motivated and more explanatory constructs.

Apart from the specific work cited in §2.4, other work fitting into this general line of research (in the case of directionality, at least) includes work in OT conducted under the general rubrics of positional faithfulness (on which see §5.2 below) and positional markedness (Zoll 1998, Walker 2001ab, Wilson 2000, 2001, 2003). In my own work (Bakovic 1999, 2000), I have argued that dominant-recessive vowel harmony — for which underspecification has been particularly entrenched — is better analyzed in terms of what I call *assimilation to the unmarked*. Finally, the complex behavior of harmonically unpaired

vowels in the dominant-recessive harmony patterns of the Eastern Nilotic languages Maasai (Tucker & Mpaayei 1955) and Turkana (Dimmendaal 1983) have been argued to necessitate separate statement of two directional vowel harmony processes by Archangeli & Pulleyblank (1994, for Maasai) and Noske (1990 *et seq.*, for Turkana); I have argued (Bakovic 2000, 2001ab, 2002, in preparation) that these cases in fact constitute further evidence for the overall stem identity approach advocated in the present article.

5   Other approaches to stem identity

So far in this article I have demonstrated the importance of the stem precedence generalization (17) and that the stem identity analysis captures this generalization directly, whereas it must be independently stipulated under alternative analyses in terms of directionality or underspecification. Furthermore, I have shown that these stipulations are generally unsuccessful to various degrees. In this section, I compare the proposed implementation of the stem identity analysis in terms of stem-affixed form faithfulness with two specific alternative implementations of the general stem identity idea from the literature.

5.1   Standard cyclicity

The proposed stem-affixed form faithfulness account shares most in common with Kaye's (1971) cyclic account of nasal harmony in Desano. Under Kaye's analysis, a (nondirectional) nasal harmony rule applies first to the innermost morphological constituent, then to the next outer constituent, and so on, in typical cyclic fashion. Each constituent must in addition be marked as an exception to nasal harmony at the end of every cycle, in order to prevent the rule from applying backward from affix to stem. This exception marking essentially achieves stem identity, and is thus the equivalent of stem-affixed form faithfulness in the analysis proposed here.

　　　One obvious problem with exception marking of this type is that it must somehow cyclically mark each stem constituent as an exceptional *nontarget* of harmony only — these stems must still serve as harmony *triggers*, lest harmony stop after the very first cycle (and hence not function at all, except perhaps within individual morphemes). The desired effect is that as each affix is cyclically incorporated into the stem it changes from a harmony target to a harmony trigger. Simply marking each stem as an 'exception' to harmony does not quite achieve this effect.

　　　Regardless of how Kaye's exception marking is actually formulated, however, it is unfortunately not possible to derive it from an independently motivated cyclic principle. The Strict Cycle Condition (SCC; Kean 1974, Mascaró 1976), for example, prevents a cyclic rule *R* in a given cycle *C* from recognizing a string meeting *R*'s structural description if and only if that string is entirely contained within a cycle prior to *C*; that is, *R* applies in *C* if and only if *either the target or the trigger* of *R* (or both, under most if not all formulations of the SCC) is contained in the new affix material introduced in *C*. Unfortunately, any modification of the SCC such that *R* applies *if and only if the target* of *R* is newly introduced in *C* would simply negate many of the positive empirical results that originally motivated the SCC.[31]

　　　In a footnote toward the end of his article, Kaye (1971:55) suggests a possible alternative to his exception marking convention. Following Kuroda's (1967) work on cyclic rule application in Yawelmani, crucial reference can be made to a morpheme boundary in the context of the nasal harmony rule "to prevent its reapplication to a given morpheme." Implicit in this alternative is a crucial interaction with cyclic bracket erasure: in each cycle, nasal harmony only has access to the bracket that has not been

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[31] Perhaps the most discussed case of this kind is Finnish Assibilation, which is claimed to apply in derived environments only. The argument in the text thus also applies to other principles intended to account for nonderived environment blocking, such as the (Revised) Alternation Condition (Kiparsky 1973) and related proposals (most recently, see Kiparsky 1993, Anttila 2000, Burzio 2000, Inkelas 2000, Cho 2002, Lubowicz 2002, Iverson 2003).

erased prior to its application — the morpheme boundary outside the affix introduced on that cycle.[32]
Kaye's reformulation of the nasal harmony rule is as in (27).

(27)   Kaye's (1971:55, fn. 15) suggested reformulation of nasal harmony in Desano

$$[X] \rightarrow [\alpha \text{ nasal}] \, / \, {}^*[\alpha \text{ nasal}] \, \underline{\quad} \,]$$

The asterisk in the context of this rule is meant to indicate that it also applies in the mirror-image envi-
ronment, [__ [α nasal]. This alternative thus reintroduces all of the problems associated with direction-
ality: it is a complete accident that the rule's target is to the right of the trigger under suffixation and to
the left of the trigger under prefixation; things could have just as easily been the exact opposite. Stem
identity is thus achieved despite the rule, not because of it.
        It is important to note that Kaye's suggested reformulation of the nasal harmony rule follows on
the heels of his lamentation of the apparent fact that "the convention which marks morphemes as excep-
tions to [nasal harmony] after its application in each cycle […] is not typical of cyclically applied rules
and hence complicates the phonology." Given the independent success of stem-affixed form faithfulness
in accounting for classic cases of cyclicity in addition to cases that are recalcitrant under standard cyclic-
ity (see Benua 1997, Kager 1999ab, and Kenstowicz 1996), Kaye's negative assessment of his own ap-
parently prescient contribution seems to have been premature.
        Finally, this discussion of Kaye's cyclic analysis of Desano nasal harmony would not be com-
plete without addressing Clements' (1976 [1980]:28*ff*) independent critique of it as a possible approach to
root-outward vowel harmony. Clements applies Kaye's analysis to a particular variety of Turkish in
which rounding harmony interacts with a process known as palatal umlaut, by which a short vowel im-
mediately preceding a palatal consonant is unrounded under certain conditions, leading to round-
disharmonic forms. (There is also a raising of nonhigh vowels under certain more specific conditions
which is not germane to the argument.)

(28)   Turkish rounding harmony and palatal umlaut (Clements 1976 [1980]:33)

   a.   /√o̱kI + m*I*ʃ/   →   [o̱kumiʃ]
        read + N.PAST   'is said to have read'
   b.   /√gü̱m*I*ʃ + tIr/   →   [gü̱miʃtir]
        silver + PRED   'it is silver'

        In the first example (28)a, the initial root vowel is [+round] and is therefore expected to trigger
[+round] harmony onto following high vowels. (I am simply following Clements' assumptions here, that
it is the initial vowel of the root that triggers harmony and that subsequent nonopaque root vowels, like
alternating affix vowels, are underspecified.) The italicized high vowel of the narrative past suffix pre-
cedes a consonant that triggers palatal umlaut; it therefore surfaces as [–round] (and [+back], independ-
ently due to backness harmony from the root). The result is thus a disharmonic form. Likewise with the
second example (28)b, except this time it is the italicized second vowel of the root that precedes an um-
laut-triggering palatal consonant. This [–round] vowel thus disagrees with the initial [+round] root vowel
(though both surface as [–back] due to backness harmony). The subsequent vowel of the predicative suf-
fix alternates to agree with the [–round] value of the adjacent, palatal-umlauted vowel of the root.
        The second example just discussed shows that a vowel unrounded by palatal umlaut, as one might
expect, behaves opaquely with respect to rounding harmony, because alternating vowels in subsequent
suffixes are also unrounded. As Clements (1976 [1980]:33) explains, the interaction between rounding
harmony and palatal umlaut in this example can be derived if both rules are cyclic and if the former pre-

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[32] That is, if bracket erasure applies by convention at the *beginning* of every cycle. As Pesetsky (1979) points out,
bracket erasure must apply at the *end* of every cycle in order to maintain the morphologically-derived environment
results of the Strict Cycle Condition.

cedes the latter (and furthermore, if rounding harmony but not palatal umlaut is subject to Kaye's exception marking convention or some equivalent). Clements' discussion of the derivation of the two forms in (28) makes the necessary analysis clear:

(29)   Cyclic interaction of rounding harmony and palatal umlaut (Clements 1976 [1980]:33)

    a.   Re: (28)a. "Rounding Harmony accounts for the final rounded vowel of the root on the root cycle; Palatal Umlaut is not defined. On the affix cycle, Rounding Harmony first rounds the affix vowel, and then Palatal Umlaut unrounds it; if we assume the opposite order, we would incorrectly have a final rounded vowel."

    b.   Re: (28)b. "On the root cycle, Rounding Harmony first rounds the final root vowel, and then Palatal Umlaut unrounds it. On the affix cycle, the affix vowel is unrounded by Rounding Harmony, giving the correct form."

What these two examples share in common, and what makes their analysis as just outlined possible, is that the trigger and target of palatal umlaut are within the same morpheme: both in the affix in (28)a, both in the root in (28)b. The analysis falls apart, however, when one considers certain cases in which the trigger and target of palatal umlaut are in different morphemes. As the following example shows, the target of palatal umlaut is still opaque to rounding harmony.

(30)   Turkish rounding harmony and palatal umlaut (Clements 1976 [1980]:33)

    /√üt*I* + yI/   →   [ütiyi]   *cf*. [ütü] 'iron (NOM)'
    iron + ACC   'iron (ACC)'

As Clements (1976 [1980]:34) demonstrates, the final root vowel in this example would be rounded by rounding harmony on the first cycle (as in the unaffixed nominative form shown for comparison on the right), but palatal umlaut would not unround this vowel yet because the palatal consonant trigger is not introduced until the accusative suffix cycle. The ordering of rounding harmony before palatal umlaut, which is necessary to correctly derive (28)a, thus gives the wrong result on this second cycle: rounding harmony rounds the affix vowel, and palatal umlaut unrounds the final root vowel. The incorrect result would be the doubly-disharmonic form *ütiyü*. Clements thus concludes that a cyclic account of root-outward vowel harmony is untenable.

Clements' argument is sound, but it is crucially dependent on the assumption that each cycle consists of a set of (totally) ordered rules. The proposed constraint-based OT analysis in terms of stem-affixed form faithfulness can straightforwardly account for the interaction between rounding harmony and palatal umlaut. The crucial observation, made by Clements himself, is that a vowel that undergoes palatal umlaut is opaque. Therefore, "it does not necessarily agree with the vowel(s) to its left [i.e., in the stem of affixation — EB]; however, the vowel to its right [i.e., in a subsequent affix — EB] must agree with it." The formalization of this observation under the proposed analysis is that the constraint responsible for palatal umlaut must be undominated, just like any constraint responsible for the opacity of a vowel. The only difference in this case is that the palatal umlaut constraint must also dominate stem-affixed form faithfulness, since this process changes the rounding of stem vowels. (Note that this is the equivalent of Clements' assumption that palatal umlaut is not subject to Kaye's exception marking convention.)

(31)   Turkish rounding harmony and palatal umlaut

Input: [ütü] + yI

Candidates	PALATAL UMLAUT	SA-IDENT[±round]	AGREE[±round]
a. [ütüyi]	* !		*
b. [ütüyü]	* !		
c. ☞ [ütiyi]		*	*
d. [itiyi]		** !	
e. [ütiyü]		*	** !

The first two candidates in the tableau in (31) are alternative attempts to maintain satisfaction of stem-affixed form faithfulness at the expense of palatal umlaut; they are distinguished by the degree to which they are harmonic. In either case, the top-ranked constraint responsible for palatal umlaut rules these candidates out. The competition thus narrows down to the last three candidates. The first of these (c) is optimal because it violates stem-affixed form faithfulness and agreement each only once, due to the unrounded final stem vowel in the palatal umlaut context. The only alternatives are to fatally violate stem-affixed form faithfulness or agreement even more, as in (d) or (e). The opaque behavior of palatal-umlauted vowels is thus accounted for.

In sum, Kaye's (1971) cyclic analysis of nasal harmony in Desano is a clear forerunner to the present stem identity analysis. The major problems arising from Kaye's analysis, some noted by Kaye and others by Clements (1976 [1980]), are primarily a function of the larger framework in which Kaye's analysis was of necessity embedded at the time. As shown elsewhere in this article, the stem-affixed form faithfulness analysis successfully avoids all of these problems, and as shown in this section, Kaye's central proposal is vindicated in the face of Clements' critique.

5.2   Root-specific faithfulness

Another alternative to stem-affixed form faithfulness that must be considered is one based on root-specific faithfulness. Root-specific faithfulness encounters significant problems in the analysis of stem identity, some familiar from the assessment of underspecification work in §4.4 above and others particular to Beckman's (1995, 1997, 1998) extensive development of the general theory of position-specific faithfulness, upon which the following is based.[33]

A root-specific faithfulness constraint is one that specifically targets the root for faithfulness evaluation: it is only violated by input-output discrepancies in the root. Input-output discrepancies in affixes are regulated by a general faithfulness constraint that targets roots and affixes alike. There can also be even more specific faithfulness constraints, such as ones that target the root-initial syllable; this is in fact Beckman's proposal in her analysis of vowel harmony in Shona. The distinction between these two types of constraint is not immediately relevant in the following discussion.

Root-outward vowel harmony is enforced under Beckman's theory not by a specific harmony-inducing constraint like AGREE[±*hf*] but rather by the interaction of featural markedness constraints with

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[33] Work originally citing the utility of root-specific faithfulness within OT includes McCarthy & Prince 1994 and Selkirk 1994, 1995. Other work on position-specific faithfulness includes Casali 1996 [1998], 1997, Lombardi 1996ab, 1999, Padgett 1995ab, and references cited therein.

root-specific faithfulness and general faithfulness.[34] The markedness constraints require a special inter-
pretation: they are violated by featural autosegments themselves rather than by the segments that bear
them. These constraints thus crucially distinguish between representations in which two or more seg-
ments share an autosegment and those in which each segment bears its own autosegment, in general pre-
ferring autosegmental sharing; that is, harmony. The ranking of constraints that ensures root-outward
harmony is as follows:

(32)   Root-outward harmony with root-specific faithfulness (Beckman 1995, 1997, 1998)

ROOT-IDENT[±*hf*] >> { *[+*hf*], *[–*hf*] } >> IO-IDENT[±*hf*]

The undominated rank of root-specific faithfulness ensures that whatever harmonic feature speci-
fication the root is underlyingly associated with will survive in the optimal output. The ranking of the
featural markedness constraints above general faithfulness, however, ensures that harmonic feature speci-
fications will otherwise be minimized. Autosegmental spreading from the root is the optimal way to
achieve this minimization while satisfying undominated root faithfulness.

The immediate difficulty encountered by this analysis is with the behavior of opaque vowels and
the stem precedence generalization. Because opaque vowels must be specified for one or the other value
of the harmonic feature, it cannot be guaranteed that the harmonic feature value of the root (more gener-
ally, of a vowel closer to the root) will always prevail over the value of the opaque vowel in determining
the harmonic fate of any vowel in between. Since spreading is compelled only by minimization of feature
specifications, whichever harmonic feature value is *least marked* is predicted to spread, depending on the
relative ranking of *[+*hf*] and *[–*hf*]. Even if markedness could somehow be rendered irrelevant, the de-
cision falls to the lowest-ranked general faithfulness constraint, predicting that a contrast in the harmonic
feature value will emerge in this context. As discussed at length in §4, neither of these predictions is cor-
rect: alternating vowels in the context under discussion never fail to agree with the harmonic feature
value of the nearest vowel in the stem of affixation. Stem precedence must thus be independently stipu-
lated under the root-specific faithfulness analysis of stem identity.

The other, more parochial problem facing the root-specific faithfulness analysis has to do with the
analysis of a language like Turkish, in which there are phonologically predictable opaque vowels that are
nevertheless harmonically paired in the language as a whole.[35] Recall from §4.4.3 that in Turkish, [–high]
vowels are opaque to [±round] harmony even though they appear to be harmonically paired; that is, even
though both [–high, –round] *a,e* and [–high, +round] *o,ö* otherwise exist in the language. The catch is that
the [–high, +round] vowels *o,ö* are restricted in their distribution to the root-initial syllable, suggesting a
distinction between the initial and noninitial vowel inventories of Turkish.[36] (This kind of distinction is
cross-linguistically common, independently of harmony; see Beckman 1998 and references therein.) Be-
cause Turkish is exclusively suffixing, noninitial vowels are independently the targets of harmony;
[–high] vowels are thus opaque to [±round] harmony because they are harmonically unpaired in the non-
initial vowel inventory.

The distributional distinction is by itself good evidence for something like a root-specific faith-
fulness constraint (more specifically, root-initial syllable faithfulness), but its interaction with root-
outward vowel harmony makes an analysis of both phenomena in terms of this one mechanism severely
problematic. The basic problem has to do with Beckman's feature-centric view of markedness: since
feature spreading does not incur additional markedness violations, a (marked) [–high, +round] vowel in a
root-initial syllable has the potential to parasitically license further such vowels in noninitial syllables. To

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[34] Beckman does not reject agreement constraints completely; they are employed, for example, in her analysis of
voicing assimilation in Catalan (Beckman 1998:27*ff*).

[35] I thank Jill Beckman for discussion of this particular issue.

[36] These vowels are additionally found noninitially in a few obvious loanwords (e.g. *pilot* 'pilot', *ʃoför* 'chauf-
feur'), and *o* appears as an idiosyncratically opaque vowel in a handful of suffixes (e.g. the progressive –*(I)yor*).

prevent this, an additional constraint must be invoked that is violated either (a) by feature-sharing specifically between [–high, +round] vowels or (b) by noninitial [–high, +round] vowels. Both of these alternatives are ad hoc stipulations, and the second alternative in particular — a position-specific markedness constraint — assumes what should properly be the function of root-initial syllable faithfulness under this analysis.

Under the proposed stem-affixed form faithfulness analysis, there is of course still a role to be played by root-initial syllable faithfulness in accounting for the Turkish facts; namely, in defining the distributional distinction that exists between root-initial syllables and noninitial syllables. The root-outward pattern of vowel harmony, on the other hand, is defined by the same interaction of stem-affixed form faithfulness and agreement already discussed at length in this article. This account does not unify the distributional pattern with the pattern of harmony, but as just demonstrated, it appears that such unification is impossible in any case.

5.3   Summary

In this section, two alternatives to the proposed analysis of stem identity were considered and were each found to be inferior to stem-affixed form faithfulness. Kaye's (1971) cyclic analysis, though clearly an important precursor to the present analysis, is problematic in ways noted by Kaye himself and by Clements (1976 [1980]). As discussed above, however, these problems appear to be entirely due to the larger theoretical framework within which Kaye's analysis was necessarily couched at the time. The stem-affixed form faithfulness analysis can thus perhaps be seen as a kind of liberation of Kaye's insightful analysis from the shackles of those assumptions.

Beckman's (1995, 1997, 1998) root-specific faithfulness analysis of root-outward harmony, though initially promising because of its appeal to the mechanism responsible for the independently observed distributional distinction that often exists between roots and affixes, was shown above to flounder precisely in a language like Turkish that exhibits an interaction between such a distributional distinction and root-outward vowel harmony. More importantly, root-specific faithfulness is unable to account for the core stem precedence generalization as it applies to the behavior of opaque vowels, which was argued in §4 to be the core empirical generalization to be accounted for by any successful analysis of root-outward vowel harmony.

Although it is somewhat beyond the scope of this article to be discussed fully here, it should be noted that there is probably still an important role to be played by root-specific faithfulness in the analysis of root-outward vowel harmony. Languages with root-outward vowel harmony can be roughly divided into those in which polysyllabic roots exhibit the same pattern of harmony as root + affix combinations and those that do not (or at least, not exactly).[37] The latter type of language is said to have *disharmonic roots*. This division between languages is plausibly related to the observation that languages sometimes exhibit more contrasts in roots than in affixes: a language with both harmony and more contrasts in roots is one that has disharmonic roots.[38] The role of root-specific faithfulness in such languages, then, is to be highly ranked enough (i.e., above agreement) to block harmony within roots.

A more complicated situation is a language in which the pattern of harmony within polysyllabic roots is *exactly* like the pattern of harmony in root + affix combinations, right down to the behavior of opaque vowels. For example, most analyses of Yoruba vowel harmony in the literature do not make the assumption that I do here (based on the independent work cited in footnote 7) that most if not all polysyllabic words are morphologically decomposable into prefixed roots. According to these alternative analy-

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[37] Much earlier work on root-outward vowel harmony within generative phonology debated the relative merits of accounting for harmony within morphemes and between morphemes with the same or separate mechanisms.

[38] Turkish is perhaps the most written-about language with harmony and with disharmonic roots (Clements & Sezer 1982, Kirchner 1993); see footnote 30.

ses of Yoruba vowel harmony, the pattern of opaque vowel behavior is exactly the same within polysyllabic roots as across morphemes. Such a situation is not accounted for under the analysis proposed here.

However, on the other side of the coin are languages like Tangale, which Kidda (1985) describes as having no low vowel opacity within roots. All other vowels in polysyllabic roots with a low vowel *a* are necessarily [−ATR] in agreement with the *a*; low vowels are otherwise simply opaque in affixes. This pattern receives a natural account under the stem identity analysis, where disharmonic opacity obeying the stem precedence generalization is only expected across morphemes. Because low vowels are harmonically unpaired and because stem identity is irrelevant within morphemes, harmony applies to a root with a low vowel in the only way that it can: by making the other vowels in the root agree with the low vowel. Directionality and underspecification accounts must make special provisions for this kind of pattern, such as allowing morphemes to have at most one [±ATR] specification.

There is a clear analytical trade-off here, but I hope to have shown in this article that the advantages of the stem identity analysis of root-outward vowel harmony far outweigh the potential difficulties — shared to some extent by many analyses of vowel harmony — in accounting for harmonic patterns within polysyllabic morphemes.

6   Concluding remarks

I have offered in this article an analysis of root-outward vowel harmony that is dependent on a general mechanism that I have dubbed *stem identity*, specifically implemented in terms of stem-affixed form faithfulness constraints of the kind independently proposed by Benua (1997). This analysis makes direct sense of the centrality of the root in root-outward vowel harmony and parsimoniously captures what I have argued to be the core empirical generalization about vowel harmony, that stem vowels never alternate to agree with affix vowels even if disharmony is the inevitable result (the *stem precedence* generalization). This analysis lends support to the general view that the phonological and morphological components of a grammar interact in the cyclic manner originally proposed in Chomsky, Halle & Lukoff 1956 and Chomsky & Halle 1968, and that the phonological integrity of stems can be specifically maintained in certain ways as those stems are cyclically derived.

Alternative analyses in terms of directionality or underspecification, or even both, were shown to be inadequate in accounting for stem precedence, even in work that has explicitly noted the importance of this generalization. One important conclusion to be drawn from this investigation is thus that what has long appeared to be motivation for directionality or underspecification in the analysis of featural phonological processes, vowel harmony and otherwise, must continue to be thoroughly and critically revisited in phonological theory, as it in fact has been in much work over the past decade or more.

An important precursor to the proposal made here is Kaye 1971, where a specific additional mechanism to ensure the phonological integrity of cyclically derived stems was proposed. This analysis was demonstrated here (and in Clements 1976 [1980]) to confront difficulties related to the theoretical framework in which it was embedded, and it was shown that the stem-affixed form faithfulness analysis straightforwardly avoids these difficulties. This could perhaps be viewed as an argument for the superiority of OT over the traditional rule-based framework, but I prefer to think of it as a sign that Kaye's analysis was ahead of its time in important respects that can now be better appreciated. Whether or not OT is the right framework in which to couch the general stem identity analysis argued for here is beside the point; the important thing is to capture what I hope to have convinced the reader is the linguistically most significant generalization forming the basis of all known cases of root-outward vowel harmony.

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