

# 14 Vowel Harmony

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## 0 Introduction

### 0.1 Goals

This chapter contains a discussion of the phenomenon of *vowel harmony* (henceforth VH). We start with a few straightforward examples and an introduction to some of the relevant terminology (sec. 0.2). Three issues will receive special attention throughout this chapter, viz., the domain of vowel harmony, the nature of the (vowel) features that participate in vowel harmony, and the fact that vowel harmony involves a relation between nonadjacent segments. These issues are introduced in section 1.

Section 2 presents an overview of harmony types in general. We do not offer extensive or detailed analyses of particular systems, nor do we attempt to develop a comprehensive theory which accounts for all aspects of vowel harmony. Our goal is both more modest and more appropriate in the context of this volume: we indicate which issues continue to come up in the theoretical analysis of this phenomenon and we discuss some of the prevailing answers to the questions these issues raise. In some cases, however, we do suggest how a particular approach could be further developed. In section 3 we discuss some cases in which consonants interfere with vowel harmony. Finally, section 4 presents some conclusions and suggestions for future research.<sup>1</sup>

### 0.2 Straightforward Examples

To set the stage for the discussion in the next sections, let us examine briefly one typical example of vowel harmony, the case of Tangale, a Chadic language spoken in Nigeria, described in Jungraithmayr (1971) and Kidida (1985). Tangale has nine vowel phonemes, which Jungraithmayr presents in the following chart:

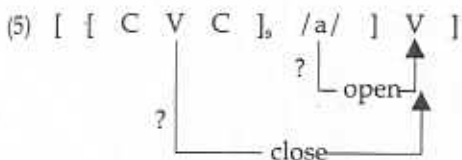


- (3) ?n kas-kɔ "I have cut"  
 ?a-nɔ "my belly"  
 war-u "go" (imp.)

The low vowel may also appear in affixes and, as we expect, these affixes do not have two allomorphs: they contain the vowel /a/, whether they appear after a stem with an open or with a close vowel:

- (4) top-a "start" (nom.)  
 tɔp-a "answer" (nom.)  
 peer-na "compelled"<sup>5</sup>  
 pɛd-na "untied"  
 la-pido "tree" (dim.)  
 la-ŋoldɛde "dog" (dim.)

The first, third, and fifth example in (4) show that neutral vowels may lead to *disharmony*, namely when the stem contains a vowel of the close set. We might now ask what happens when a second suffix is added to such disharmonic words as in (4). Will the suffix vowel agree with the stem vowel (/o/) and be close, or will it agree with the suffix vowel (/a/) and be open? This situation is presented schematically in (5):



In harmony systems of the Tangale type, it turns out that the suffix vowel agrees with the immediately preceding /a/, and not with the stem vowel:

- (6) (a) ped-na-n-gɔ "untied me"  
 peer-na-n-gɔ "compelled me"  
 dɔb-na-g-gu "called you" (pl.)  
 dɪb-na-m-gu "cooked for us"  
 (b) kulag-dɔ "her frying pan"

Tangale does have some polysyllabic stems (cf. (2)) and in a few of these the low vowel combines with a preceding close vowel. The last example, (6b), shows that in such stems, which are called *mixed*, the /a/ imposes its openness on the suffix vowel. We may say, then, that in general the neutral low vowel imposes its value on vowels in following syllables.

It has been claimed, however, that this may vary from language to language and indeed there are cases in which suffix vowels agree with the vowel which

precedes a neutral vowel; it seems as if in such cases the neutral vowel is completely ignored. The latter type of vowels are referred to as *transparent*, as opposed to the low vowel in Tangale which is called *opaque*. Transparent neutral vowels occur in the vowel harmony system of Finnish.

Finnish has the following vowel inventory (see, e.g., L. Anderson 1975, 1980):

(7)		front		back		
	non-round	round	non-round	round		
	i	ü		u		high
	e	ö		o		mid
	æ		a			low

Each vowel may be short or long.

Finnish vowel harmony is based on the front-back opposition, and is an example of a *palatal harmony* system. Vowels within a word must either be all front or all back. (This statement ignores a number of subtleties that we will deal with later.) Note that /i/ and /e/ have no back counterparts; hence these vowels are neutral.

Some examples (taken from Ringen 1975; Kiparsky 1981) are given in (8) (phonetic /æ/ corresponds to orthographic ä):

(8) Front words		Back words	
väkkärä	"pinwheel"	makkara	"sausage"
pöytä	"table"	pouta	"fine weather"
käyrä	"curve"	kaura	"oats"
tyhmä	"stupid"	tuhma	"naughty"

As expected, suffixes show front and back alternants depending on the quality of the stem vowel(s) (Finnish has no prefixes):

(9)	tyhmä-stä	"stupid" (ill.)	tuhma-sta	"naughty" (ill.)
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Consider now the behavior of the two neutral vowels /i/ and /e/. In (10) we give examples of mixed stems, in which these neutral vowels cooccur with either front or back stem vowels:

(10) Front words		Back words	
värttinä	"spinning wheel"	palttina	"linen cloth"
isä	"father"	iso	"big"
kesy	"tame"	verho	"curtain"

If the neutral vowel is preceded by a back vowel and occurs in the stem-final syllable, the suffix alternant is back, which shows that neutral vowels in Finnish are *transparent*:

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## (11) tuoli-lla "on the chair"

Thus, neutral vowels may behave in two ways. Tangale /a/ is opaque. A preceding close vowel does not impose its closeness on a vowel which follows /a/. Such a following vowel will therefore agree with /a/ in being open. Below we will see that we can interpret this in two ways: we may say that /a/ spreads its openness to a following vowel, or we may say that opaque vowels (or neutral vowels in general) do not spread their value, and vowels following an opaque vowel show up with a default value, which in Tangale happens also to be the value of the neutral vowel /a/. The situation in Finnish is different, however. A vowel following /i/ or /e/ takes on the value of the vowel that precedes the neutral vowel. If a front vowel precedes the neutral /i/ or /e/, suffixes show up with front vowels:

- |                     |  |                                    |
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| (12) Front words    |  |                                    |
| värttinä-llä-ni-hän |  | "with spinning wheel, as you know" |
| lyö-dä-kse-ni-kö    |  | "for me to hit"                    |
| Back words          |  |                                    |
| palttina-lla-ni-han |  | "with linen cloth, as you know"    |
| lyö-da-kse-ni-ko    |  | "for me to create"                 |

As in the case of Tangale /a/, the neutral vowels /i/ and /e/ in Finnish behave the same whether they are part of the stem or of a suffix (as the examples in (12) demonstrate). One interpretation is that, as before, the neutral vowels do not spread their value, and that vowels that follow the neutral vowels do not receive the default value, but the value of the preceding vowels. On this account, Tangale /a/ differs from Finnish /i/ and /e/ as a result of a parameter setting: whereas /a/ is specified as opaque, /i/ and /e/ are specified as transparent, the choice being a language-specific one.

Perhaps, however, the behavior of neutral vowels as either transparent or opaque can be predicted from general principles, rather than be stipulated on a case-by-case basis. In a given harmonic system, neutral vowels may have the active value of the harmonic feature, i.e., the value that spreads, or the passive value, i.e., the value that is assigned by default rule (see sec. 1.2.1 for a further clarification of these terms). Van der Hulst and Smith (1986) argue that in the former case the invariant vowels act as transparent, and that in the latter case they act opaquely, regardless of whether these vowels appear in a stem or an affix. Assuming that in Tangale [ATR] is the active value, the prediction is made that the low vowel is opaque since it is incompatible with this value. In Finnish [front] spreads, which is a value that both /i/ and /e/ can obviously bear. There are problematic cases for this approach as well: for a detailed discussion of these, see van der Hulst (1988a, 1988b).<sup>6</sup>

A further topic of considerable interest is the fact that most vowel harmony systems allow *disharmonicity* even where neutral vowels are not involved. First, polysyllabic stems may contain non-neutral vowels from opposite harmonic

sets, and second, certain affixes may fail to harmonize with the stem even though they do not contain a neutral vowel. Such morphemes are referred to as disharmonic stems and disharmonic affixes, respectively. Often, but not always, disharmonicity results from unassimilated loan stems or loan suffixes.

We will illustrate disharmonicity with examples from Hungarian, which, like its relative Finnish, has palatal harmony. The dative suffix, for instance, has two variants: one with the front vowel /e/ and one with its back counterpart /a/ (pronounced [ɔ]). Consider the behavior of this suffix after the following disharmonic roots:

- (13) *sofőr:nek* "driver" (dat.)  
*büro:nak* "bureau" (dat.)

It would appear that the *last* vowel of the disharmonic root determines the quality of the suffix vowel, i.e., the backness of /o/ does not spread across the front vowel /ø:/ and the frontness of /ü:/ does not spread across back /o/. Put differently, /ø/ and /o:/ behave opaquely.<sup>7</sup> We return to the representation of disharmonic roots below.

Vago (1980a) lists a number of invariant suffixes in Hungarian. Consider the following suffixes from Hungarian (we use standard spelling except for the vowels):

- (14) -kor, -us, -u, -ko:, -a

The suffixes in (14) have only non-neutral vowels (which all turn out to be *back*). If another suffix with a vowel that could harmonize is added, this vowel is back, even if the stem vowel is front. Examples are given in (15):<sup>8</sup>

- |                      |                         |
|----------------------|-------------------------|
| (15) Diminutive name | Instrumental            |
| Évus (Éva+us)        | Évus-nak                |
| Gittus (Margit+us)   | Gittus-nak              |
| Petyus (Péter+us)    | Petyus-nak              |
| Rékus (Réka+us)      | Rékus-nak               |
| Terus (Teréz+us)     | Terus-nak               |
| Tündüs (Tünde+us)    | Tündüs-nek <sup>9</sup> |

The combination of a front-vowel stem and a disharmonic back suffix behaves identically to a simple disharmonic stem such as *büro:* the vowel immediately preceding the suffix determines the harmony.

To summarize, disharmonicity on the phonetic surface may have two distinct sources. Neutral vowels are invariant on phonological grounds. They may occur with vowels from the opposite set. As such they form "harmonic islands" (if they are transparent) or initiate a new "harmonic span" (if they are opaque). Disharmonicity may also have a *lexical*, i.e., idiosyncratic basis. This is the case

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Even though we will discuss cases which differ in several ways from Tangale, Finnish, and Hungarian, the prototypical situation is that all vowels (regardless of their number) within a particular domain, usually said to be the (prosodic) word, agree with each other for one of their properties; interruptions of this pattern are due to neutral vowels or lexical exceptions.

## 1 Three Crucial Issues

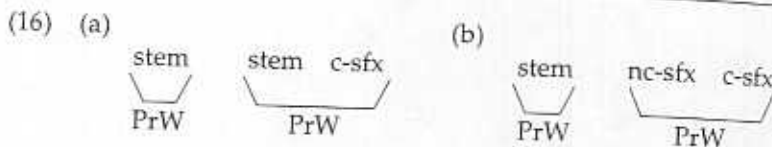
### 1.1 The Harmonic Domain

Vowel harmony requirements are usually claimed to hold within the "word." The relevant notion of word is not necessarily that of the (complete) grammatical word, however. One case which frequently shows a mismatch between grammatical word and harmony domain is that of *compounds*, which, although single words grammatically, usually constitute as many harmonic spans as they have stems.<sup>10</sup> The phonological independence of compound constituents is relevant in a variety of phenomena, involving both stress and segmental processes, and in these cases members of compounds are said to form separate prosodic words.

This is in fact also the principal reason for postulating that the typical domain of vowel harmony is the *prosodic* word, rather than defining the domain in morphosyntactic terms. In this section we raise some questions with respect to the domain issue. There are two main arguments that suggest that characterizing the domain as the prosodic word is not completely satisfactory.

First, processes which make reference to higher-level prosodic categories such as the prosodic word are usually fully automatic, and often allophonic and "optional" (i.e., post-cyclic and perhaps even post-lexical). Vowel harmony is typically rather different in this respect, since it often has exceptions and is usually neutralizing and "obligatory." This suggests that vowel harmony is somewhat anomalous among the phonological processes that refer to prosodic categories.

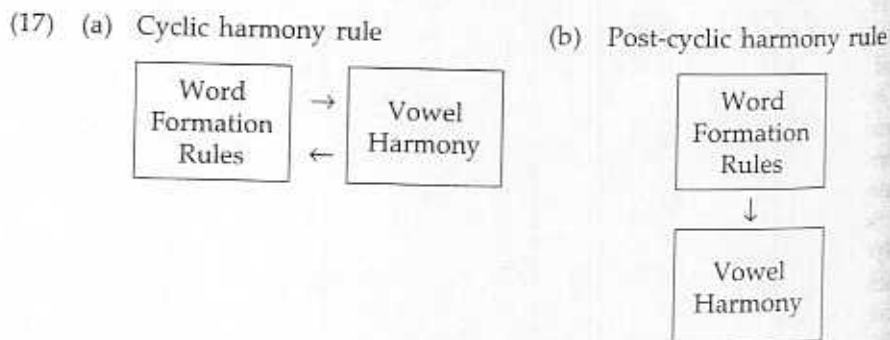
Second, if the harmonic domain is indeed the prosodic word, we might expect to find cases of vowel harmony which take stems as their domain including only those affixes which form one prosodic word with their base, and excluding affixes which form a prosodic word by themselves. Following Booij and Rubach (1984), we refer to the former type of affixes as *cohering* affixes. If the prosodic word is the domain for vowel harmony we expect noncohering affixes to behave like members of compounds and, furthermore, that cohering affixes added to a noncohering affix will harmonize with the latter. We illustrate both cases in (16) (c=cohering; nc=noncohering):



Contrary to what one might expect, analyses of vowel harmony never make reference to a distinction between cohering and noncohering affixes, so far as we are aware. Rather, if certain affixes fail to agree with the stem this is usually regarded as an idiosyncratic property of these affixes (i.e., they are lexically marked as disharmonic), and no independent evidence is supplied to show that these suffixes form independent prosodic words. In fact, in the case of vowel-initial suffixes, syllabification evidence indicates that they are not (cf. (15) above, where *Rékus* is syllabified *Ré.kus*, not *Rék.us*).

Third and perhaps most important, the existence of disharmony *within* prosodic words, we believe, invalidates the claim that prosodic words form the domain of vowel harmony. An alternative hypothesis concerning the vowel harmony domain is that vowel harmony applies with direct reference to the morphological structure, i.e., at some level in the morphological derivation, assuming a notion of level in the sense of Siegel (1974) or Kiparsky (1982). On this view of the domain issue, however, one would expect harmony systems in which all affixes on a particular level fail to harmonize, as well as affix-ordering effects, i.e., cases in which nonharmonizing affixes would be peripheral to harmonizing ones, or vice versa. We are, however, unaware of descriptions of vowel harmony systems that point clearly in this direction. Still, a positive argument in favor of the hypothesis that vowel harmony is sensitive to morphological structure in some way or other is the fact that inflectional affixes are usually more regular undergoers of harmony than derivational affixes.

A further issue concerns the question whether vowel harmony applies cyclicly or not. The two possibilities are schematized in (17):



Descriptions and analyses of vowel harmony in the literature are often compatible with either option.<sup>11</sup>

We do not exclude the possibility that vowel harmony may take place within prosodic constituents. Foot-level vowel harmony has been reported, for

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example in Chamorro (see Topping 1968); it appears to apply in the foot carrying the main stress.<sup>12</sup> Among the vowel harmony cases discussed in the literature there may very well be cases where the domain is indeed the prosodic word.

It has also been suggested that vowel harmony may apply in domains which are even larger than the prosodic word. This involves cases where clitics harmonize with their hosts. It has been argued that the resulting prosodic unit forms a separate level called the *clitic group*. Vowel harmony, then, may also hold at this level. Whether the clitic group and the prosodic word form distinct prosodic categories has been disputed, however.<sup>13</sup> Still, the typical case involves a morphologization of the harmony domain, although the precise characteristics remain to be worked out.

Finally, there is no reason to exclude allophonic (non-neutralizing) and/or "optional" harmony. We are aware of two examples, namely the cases of Chukchee (see sec. 2.2 below) and Sesotho (see sec. 2.3 below). Given the considerations presented above, we expect to find such cases when harmony is post-lexical and prosodically conditioned.

## 1.2 Features

The phonological representation of an utterance contains a string of syllabic positions (Xs), which form the terminal nodes of a syllabic organization and the anchor point for phonological features (see chap. 5, this volume). With respect to the phonological features, two issues are of paramount importance for the analysis of vowel harmony. The first concerns the question of whether features are *binary* or *unary*, the second, the question of how features are organized among themselves. The relevance of the syllabic organization is discussed in section 1.3.

### 1.2.1 Binary or Unary Features

There are at least two relevant approaches to phonological primes. The first views primes as *binary features* (Jakobson, Fant, and Halle 1952; Chomsky and Halle 1968). A binary feature consists of a feature name, for example [round], and a value, + or -. Segments are specified as either [+round] or [-round]. On this view, we may define *harmony* as a state in which segments agree with respect to their value for some feature within the relevant domain.

A recent development within binary feature theory is *radical underspecification theory* (see chap. 4, this volume, and Archangeli 1984, 1988; Archangeli and Pulleyblank 1989, in press). Central to this approach is the proposal that for each feature one value is specified in the lexical representation of words, i.e., it is the value which is phonologically active.<sup>14</sup> The other value, on this view, is filled in by a default rule at later stages or at the end of the phonological

derivation. This default value, then, becomes active late in the derivation (when "called upon" by a phonological rule) or is completely passive (when no phonological rule refers to it).<sup>15</sup>

It is important to realize that it may be difficult to decide which of the two values of a given feature is the active one and which is the default one on the basis of vowel harmony alone. In an exceptionless stem-controlled system, this is fundamentally impossible.<sup>16</sup> The default value can only be established in circumstances where it is certain that no spreading takes place. To make this clear, consider again the dative suffix in Hungarian, which alternates between *-nek* and *-nak* (see (13) and (15) above). Hence, on the assumption that vowel harmony is feature-filling, the vowel in this suffix is unspecified for front/backness and receives its value for this feature by spreading. However, the root *hid* "bridge", which has only a transparent vowel, takes a back vowel suffix:

- (18) *hi:d* "bridge"      *hi:d-nak* "bridge" (dat.)

One interpretation is that neutral vowels cause no spreading. In that case, the behavior of roots like *hid* is evidence that the default value in Hungarian is [+back] and hence that the active, spreading value is [-back].<sup>17</sup>

A second approach to primes holds that segments consist of *unary components* (or *elements*), so that there is a single element [Round]. On this view, an unrounded segment lacks the element [Round] and harmony may be defined as a state in which segments agree in that they all have or all lack a particular element. We will refer to this approach as *unary component theory* (see chap. 18, this volume, and Rennison 1986; Anderson and Ewen 1987; van der Hulst 1989, 1991; Ewen and van der Hulst 1985, 1988).<sup>18</sup>

The unary approach can be regarded as a radical version of radical underspecification theory. Essentially, its claim is that one and the same value is active across languages and that default values are never phonologically active in any part of the phonology. With respect to vowel harmony, radical underspecification theory and unary component theory make different predictions. All other things being equal, radical underspecification theory allows [-round] to play an active role in the phonology of a given language, whereas unary component theory can under no circumstances refer to the property of not being round, or to the class of nonround segments: it is a widespread assumption that phonological rules cannot refer to the absence of the component. This means that the two approaches make different predictions with respect to the number of possible vowel harmony systems. According to radical underspecification theory, vowel harmony involving roundness may involve either [+round] or [-round] (or perhaps both). In other words, assuming the same set of features, radical underspecification theory predicts the existence of twice as many VH systems as does unary component theory. Compared to binary theories which do not adopt radical underspecification, radical underspecification theory makes at best statistical predictions, in that

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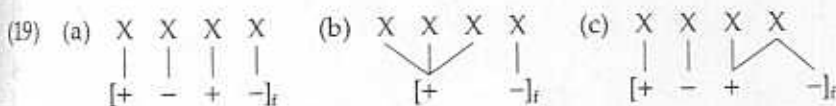
presumably vowel harmony systems based on the unmarked values are predicted to be more frequent.<sup>19</sup>

Proponents of binary feature systems have indeed argued that there are vowel harmony systems which involve [-back] and [+back], and [-ATR] and [+ATR] (as we will see below). No examples of [-round] harmony systems have been put forward. Unary systems with components like [round], [front], and [ATR] therefore must address the question how systems that are claimed to be based on [+back] and [-ATR] must be (re)analyzed. In this chapter, we will assume that the unary view is tenable. This is relatively clear for the front-back dimension and probably certain for the liprounding dimension, for which we use [front] and [round], respectively. For the tongue-root and height dimensions, however, we will make use of *two* components per dimension: [ATR]/[RTR] and [high]/[low], respectively. We view these as *pairs* of unary components.<sup>20</sup>

### 1.2.2 Relations Among Features: Autosegmental Phonology

We now turn to a second important aspect of subskeletal organization, namely the question of how features are organized among themselves, and how they are related to the skeletal positions. We will briefly outline the relevant aspects of the prevailing model, *autosegmental phonology* (Goldsmith 1976), bearing in mind that this model can be combined either with a binary-feature theory or with a unary-feature theory. We will draw attention to the possibilities and problems that both combinations lead to.

Central to autosegmental phonology is the claim that there is not necessarily a one-to-one relation between syllabic positions and features. Let us illustrate this point, first in the case of representations involving binary features. In addition to (19a), (19b), and (19c) are also possible phonological representations:



The notation introduced here is merely a typographical convenience: a series of values for the same feature *plus* the syllabic position for which they hold are enclosed within a pair of square brackets, which is labeled with the feature name. In autosegmental phonology such a structure is called a *plane*, and the sequence of values is referred to as a *tier*.

In (19a) each slot has its own specification for the feature [ $\pm f$ ], but in (19b) the first three slots *share* the same value. In (19c) the last slot is provided with two values, the first of which is shared with the preceding segment.

Assuming that the plus value corresponds to a unary component, the equivalent of (19) in unary component theory would be:

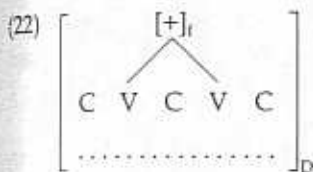


We have now introduced sufficient terminological background to proceed with a discussion of the third central issue of interest raised by the phenomenon of vowel harmony, viz., the issue of *locality*. This will lead us to discuss further developments in autosegmental phonology.

### 1.3 Locality

A question of obvious relevance in any analysis of vowel harmony is that of its *non-local* nature. Vowel harmony essentially consists of the requirement that all vowels in a certain domain must agree with respect to a certain property. If this is expressed as association of a single feature to an unspecified number of anchors, the association procedure must pick out specific types of segments (here, vowels), and the resulting configuration of multiple association will involve skipping the slots filled by consonants.

To illustrate the issue, let us for the sake of simplicity encode the distinction between vowels and consonants on the skeletal tier, so that we can use *v* and *c* instead of *X* (leaving aside the issue whether in actual fact there are two types of skeletal points or whether this distinction is purely expressed in terms of syllable structure, cf. Levin 1985a and chap. 5, this volume). A harmonic configuration appears in (22):



It is generally agreed that non-local association must be regarded with great suspicion (Steriade 1987, and chap. 4, this volume). Analyses of vowel harmony have therefore sought to reconcile the idea that vowel harmony involves feature sharing with the assumption that all feature sharing is local in some sense or another. Clearly, if vowel harmony can be shown to conform to some sort of locality, this will not be strict locality, which we will define as locality at the skeletal level.

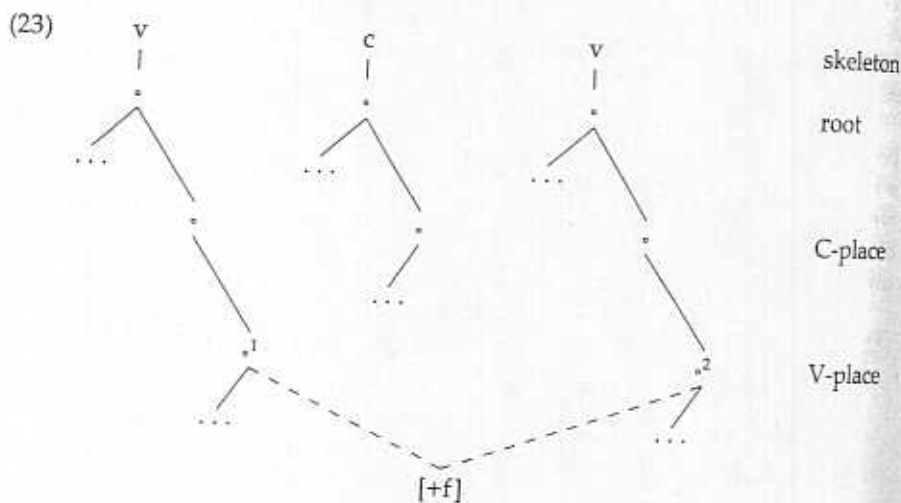
We will consider two approaches to this issue. The first is crucially based on a "geometrical" elaboration of autosegmental phonology, whereas the second is based on the idea that vowels occupy a privileged position in the syllabic organization.

#### 1.3.1 The Geometrical Approach

In an influential offshoot of autosegmental phonology, features do not associate directly to skeletal positions, but rather to *class nodes* to which features of the same kind are associated (i.e., place features under a Place node, laryngeal

features under a Laryngeal node, etc.). These class nodes in turn are associated to a *root node* and root nodes associate to skeletal slots. This approach is referred to as *feature geometry* (see chap. 7, this volume).

For our purposes one aspect of such a tree-like organization is important, viz., the claim that vowel features associate to a class node which consonants lack.<sup>22</sup> One might propose that the set of harmonic units for some harmonic feature P can quite straightforwardly be defined as the set of segments which have the class node to which P associates. In (23) below, this class node is labeled V-place (see chap. 7, this volume). Hence, as long as intervening consonants do not have a V-place node, feature sharing between vowels is local because their class nodes are adjacent.<sup>23</sup>



The consonant in (23) will be invisible when the feature [+f] is associated to the nodes labeled 1 and 2. Hence the multiple association pattern that arises is local. We will say that the consonant is legitimately skipped.<sup>24</sup>

The structure in (23) is intended to explain another fact. It has often been claimed that harmony among consonants is much rarer than vowel harmony. The structure in (23) accounts for this: since vowels have a C-place node, consonantal place features cannot spread from one consonant to another if a vowel intervenes. However, since it is not clear whether vowels *need* the C-place node, or whether a contrast could exist between vowels with and without such a node, or whether there are harmony processes which affect *all* segments with a C-place node, the C-place node on vowels seems largely a diacritic device.<sup>25</sup>

### 1.3.2 The Syllable-head Approach

There is a different line of explanation for the asymmetry noted in the previous section, which has, however, been less well developed. This approach makes

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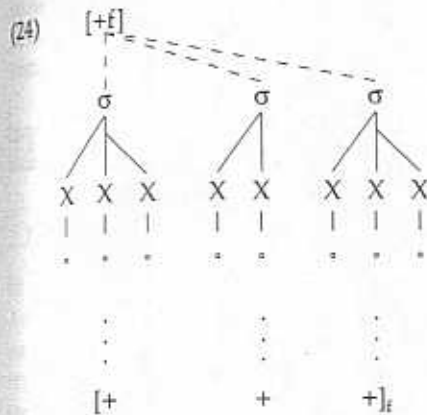
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use of the idea that vowels are syllable heads. The central idea is that vowel harmony involves a relation between syllable nodes and by implication, because vowels are syllable heads, between vowels. We shall take this idea quite literally by assuming, first, that harmonic features associate to syllable nodes and then percolate to the heads of these nodes, i.e., the vocalic root nodes.



Lexically, no relation between [+f] and syllable heads need be assumed, just as in what may be called the "standard" autosegmental approach discussed in the previous section. Moreover, if it is assumed that locality is a constraint governing *all* linguistic representations, we expect that vowel harmony involves a local relation between adjacent syllable nodes.

The syllable-head approach has the advantage of making the extra geometrical apparatus in (23) largely unnecessary, while it also explains the asymmetry between consonants and vowels in vowel harmony: consonants are *not* heads of constituents which are adjacent at any level. Hence, it may lead to the possibility of developing a more restricted conception of the segment-internal geometry. A view like this has been proposed in dependency and government-based approaches to phonology (see chap. 17, this volume, and Anderson and Ewen 1987; Kaye, Lowenstamm, and Vergnaud 1985), but as yet no systematic treatment of vowel harmony has been cast in such a theory (cf. Vergnaud 1976, Hart 1981). It would seem that a "syllable-head" theory of vowel harmony is ultimately committed to the claim that vowel harmony involves a relation which is different from assimilation processes that apply strictly locally, i.e., between adjacent skeletal slots. Vowel harmony, on this view, would not involve feature sharing below the skeleton at all.<sup>26</sup>

## 2 Types of Harmony Processes

In this section we offer a typology of vowel harmony systems. In section 0.2 we presented the basic types of harmony systems: Tangale had a vowel

harmony system based on the "open-close" distinction. This has been called a "cross-height," or, in more current terminology, a tongue root harmony system. Tongue root harmony systems may be analyzed in different ways, namely by way of the feature Advanced Tongue Root [ATR], or Retracted Tongue Root [RTR], or by way of height features [high] and [low], in which case the terms aperture or height harmony seem more appropriate.<sup>27</sup> It is important to realize that this is partly a matter of theoretical interpretation and partly a result of the fact that different types of tongue root or aperture/height harmony are involved.

We will discuss a number of harmony types that involve either the tongue root dimension or aperture (or height). The literature reports harmony systems using all these features:

- (25) (a) [ATR] harmony (sec. 2.1)  
 (b) [RTR] harmony (sec. 2.2)  
 (c) [high] harmony (sec. 2.3)  
 (d) [low] harmony (sec. 2.4)

It has been pointed out by several researchers that the tongue root dimension is closely related to the aperture/height dimension. Advancing the tongue root almost inevitably leads to raising (and fronting) the tongue body; see Hall and Hall (1980) for a discussion of this correlation. *Aperture* is often used to refer to the same dimension as tongue height, but if we take this as referring to jaw opening it is strictly speaking independent of tongue body activity, irrespective of the question whether the latter is entirely determined by tongue root activity (as Wood 1981 seems to suggest). Nonetheless, it seems that aperture and height conspire to produce a single dimension along which a four-way distinction can maximally be made and that, independently of that dimension, a two-way distinction is produced by activity of the tongue root. In other words, aperture/height and tongue root are independent, even though certain correlations are strongly preferred.

The four-height aperture/height distinction calls for two vowel components, [high] and [low] which, then, can both be harmonic features. Both function in the representation of a single vowel system if more than two aperture degrees are made. We will discuss harmony systems that appear to involve either [low] or [high] spreading. We do not know of systems that involve spreading of both. Also, given the fact that [high] and [low] characterize a single dimension, it is not always clear which of the two is involved.

For the [ATR]/[RTR] distinction one component per language seems sufficient. Still, we believe there is evidence for two types of tongue root harmonies, i.e., those in which [ATR] is the spreading value and those in which [RTR] is. However, again, it is not always obvious which of the two is active.

The ambiguity between [high]/[low] and between [ATR]/[RTR] combined with the fact that both dimensions are closely related may lead the phonologist

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to hesitate between four possible analyses when confronted with a particular harmony system (i.e., those above). In fact, we believe that particular systems may be truly ambiguous, which is also suggested by the fact that historical shifts have occurred from one type to another. In sections 2.1 to 2.4 we offer a discussion of tongue root and aperture/height cases.

In section 2.6 we will deal with palatal harmony (as in Finnish and Hungarian), in section 2.7 we will deal with rounding harmony, and in section 2.8 a number of other harmony systems appear.

## 2.1 [ATR]

### 2.1.1 Root-controlled Systems

In this section we briefly discuss a number of systems which have been described as involving [ATR] or which can easily be interpreted as such. We emphasize the fact that many [ATR] systems are complicated by the various types of mergers that have taken place, creating "crazy" alternations, and by the partial reinterpretations of ambiguous aspects of such systems that have led to mixed harmony systems in which [ATR] spreading seems to co-occur with the spreading of [low], sometimes creating three-way alternations.

We focus on the African continent. [ATR] harmony may very well be an areal feature of this continent. Tongue root systems occurring elsewhere in the world, especially in Asia, more often seem to involve [RTR] spreading, although, as pointed out above, this ultimately depends on the analysis. These cases will be discussed in section 2.2.

In ATR harmony systems, segments that form harmonic pairs differ in the articulatory dimension of tongue root placement. [ATR] vowels are produced with an advanced tongue root. We will use a unary feature [ATR] to refer to vowels produced with an advanced tongue root, and [RTR] for vowels with a retracted or neutral tongue root position. An example of a harmony system based on the distinction might have the vowel system in (26):

(26) advanced tongue root		retracted tongue root	
front	back	front	back
i	u	ɪ	ʊ
e	o	ɛ	ɔ
	a		ɑ

Vowel harmony systems based on the ATR distinction are common among the Niger-Kordofanian and the Nilo-Saharan language families on the African continent; among the two other major African families there are some examples in the Afro-Asiatic family (Semitic and Chadic branches). In the other branches of this family (Cushitic and Semitic) there are also vowel harmony languages. For Cushitic we mention Somali (Armstrong 1934) and for Chadic we mention

Kera (Ebert 1974, 1979) and Ga'anda (Newman 1977). Harmony systems in Semitic languages are analyzed in Puech (1978). A number of Kru languages have full systems (e.g., Vata; see Kaye 1982). We are not aware of any cases in the Khoisan language family.

ATR-systems are typically *reduced*, i.e., they either lack the low [+ATR] vowel /a/ (27a) or the high [-ATR] vowels /i/ and /u/ (27b), or both, as in (27c) (see Williamson 1973, 1983; Lindau 1975):

(27)	(a)	advanced tongue root	retracted tongue root
		front      back	front      back
		i          u	ɪ          ʊ
		e          o	ɛ          ɔ
			a
	(b)	advanced tongue root	retracted tongue root
		front      back	front      back
		i          u	ɪ          ʊ
		e          o	ɛ          ɔ
			a
	(c)	advanced tongue root	retracted tongue root
		front      back	front      back
		i          u	ɪ          ʊ
		e          o	ɛ          ɔ
			a

The Tangale vowel harmony system has the (27a) vowel inventory. Recall that Jungraithmayr (1971) described the two sets of vowels as *close* and *open*. This used to be a common way of referring to this opposition, which was later proposed to involve the feature [ATR] (Stewart 1971; see also Halle and Stevens 1969). Before the feature [ATR] came into use, African systems were also described in terms of features referring to vowel height (open/close, high/low), or in terms of a feature [±tense]. The latter type of analysis was inspired by the fact that the distinction between the two vowel sets, especially where the mid and high vowels are concerned, is auditorily similar to the distinction between tense and lax vowels in the Germanic languages (see also Ladefoged and Maddieson 1990: 106ff.).

The mergers which are behind the reduced systems in (27) above lead to unexpected alternation:

(28)	Change in height	Alternation
	/a/ → /ɛ/, /ɔ/	/a/ - /ɛ/ (a)
		/a/ - /ɔ/ (b)
	/i/, /u/ → /e/, /o/	/i/ - /e/ (c)
		/u/ - /o/ (d)
Change in class	/e/, /o/ → /ɛ/, /ɔ/	/ɛ/ - /ɛ/ (e)
		/u/ - /ɔ/ (f)

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The above scheme i groups. If a marked v with a vowel within in its own class (ne together with its har In (29), we illustrate example:

(29)	/ɪ/ → /i/ (
	/ɪ/ → /e/ (
	/ɪ/ → /ɛ/ (

It is easy to see th synchronic analysis c disharmony effect, si non-ATR vowels. In complication of havi both the disharmony mind that it may hap and that the vowel language to languag A language which (Niger-Kordofanian, pp. 63-96).<sup>28</sup> Ogori h

(30)	i
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In stems mid /e o/ c show a remarkable s



(31)	[ATR]	—
	i	ɛ
	u	ɔ
	e	a

It seems that different patterns of merger have arisen in stems and affixes in this case.

We find remarkable patterns of reduction in the Moru-Madi languages (Chari-Nile (east) (Andersen 1986a, 1986b, Dimmendaal 1983). One language, Moru, has ten vowels on the surface and appears to be the most conservative dialect. All the other languages have reduced systems. Among the mergers that have taken place, there are two which are unexpected, i.e., the loss of the mid ATR vowels /e/ and /o/ (which merge with /I/ and /U/). The mid vowels are usually more stable than both the ATR low vowel and the non-[ATR] high vowels.

### 2.1.2 Dominant Systems

The systems described in the previous section have usually been analyzed in terms of ATR-spreading. However, it would not be easy to prove that they could not be analyzed in terms of [RTR]. A distinction between the two possibilities could be made on theoretical grounds if the behavior of the low vowel is taken into account. If the low vowel behaves as opaque it would be a theoretical indication that [ATR] spreading is involved (see van der Hulst and Smith 1986).

This indeterminacy is not present in dominant systems, since it is not stems that determine the behavior of affixes, but a given harmonic value that takes precedence. We find a number of dominant systems in the Nilo-Saharan family, especially in the Chari-Nile (east), Nilotic branch.

We consider Turkana to be an example of a dominant system, which shows an additional interesting complication (Dimmendaal 1983; van der Hulst and Smith 1986; Noske 1987; Vago and Leder, to appear; Trigo 1991). Turkana has a nine-vowel system:

(32)	i		u
		ɪ	ʊ
	e		o
		ɛ	ɔ
			a

The dominant character of Turkana vowel harmony appears from the fact that there are ATR-determining suffixes. This is shown in (33):

(33)	(a)	ak-ɪs-ɪmɔj	INF-CAUS-eat	"to feed"
	(b)	a-ɪmɔj-ɪ	1-eat-ASP	"I ate"
	(c)	ak-ɪmɔj-eeni	INF-eat-HAB	"to eat regularly"

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(36) \*...ɛ

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(37) /i/  
[front]  
[ATR]

The forms in (33a) and (33b) establish that the root vowels in the stem for "eat" are underlyingly [RTR], and the habitual suffix in (c) imposes its [ATR] value on these vowels (see Vago and Leder, to appear, p. 3).

In addition, however, some suffixes appear to spread [RTR], despite the fact that the dominant value is [ATR]. If this is correct, this would contradict our claim that [ATR] and [RTR] are never active in one language.

(34) /ɛ-ibus-a-kɪn-a / [ɛibusakɪnɔ]

The whole word is [RTR] in the presence of the last suffix /-A/.

Outside the Nilo-Saharan family we find a dominant [ATR] system in Tunen (Bantu A.44; see van der Hulst, Mous, and Smith 1986). In the next section we will consider the cases of Chukchee and Nez Perce, in which [RTR] appears to be the dominant value. We are not aware of dominant systems involving such features as [high], [low], [front], or [round].

## 2.2 [RTR]

Archangeli and Pulleyblank (1989) argue that vowel harmony in Yoruba involves leftward spreading of [RTR]. Yoruba has a seven-vowel system (ignoring nasality):

(35) /i/        /u/  
      /e/        /o/  
      /ɛ/        /ɔ/  
              /a/

The high mid vowels (e, o) and low mid vowels (ɛ, ɔ) do not co-occur, but in addition /e/ and /o/ do not occur to the left of /a/. Furthermore, /ɛ/ and /ɔ/ can only precede high vowels if the latter are word final, i.e., the sequence in (36) is illformed:

(36) \*...ɛ/ɔ - i/u - V...

Archangeli and Pulleyblank claim that the data can be straightforwardly analyzed if [RTR] spreads from right to left. /i/ and /u/ lack [RTR] counterparts and are opaque.

It is possible to analyze the Yoruba data in terms of [low] spreading if /e/ and /o/ are analyzed as the unmarked front and round vowels:

(37) /i/        /u/        /e/        /o/        /ɛ/        /ɔ/        /a/  
      [front]    [round]    [front]    [round]    [front]    [round]     
      [ATR]     [ATR]                    [low]     [low]     [low]

The most remarkable aspect of this representation is perhaps the fact that high mid vowels are represented as [ATR]-less high vowels. We do not believe that this characterization is objectionable. Given the fact that the full range of possible contrasts is not exploited, the phonological characterization cannot be established without taking the behavior of the vowels into consideration. The featural analysis in (37) permits a different view on the spreading process. Segments which in the analysis of Archangeli and Pulleyblank cause [RTR]-spread constitute a natural class here in being specified as [low].

The Tungusic languages (Altaic) provide another potential case for [RTR] harmony, although no detailed analyses are available to us which present a conclusive case.

Ard (1981, 1984) provides surveys of the vowel systems and harmonies found in these languages. His general claim is that the harmony is based on tongue position (plain vs. retracted) in the most conservative dialect of Even and on height in the other languages. Hayata (1980) and Hattori (1982), who speaks of the "open-close" type, make the same point (other sources on harmony systems of this sort are Comrie (1981) and Kim (1978), the latter of whom uses the term "diagonal vowel harmony" to refer to this type of harmony). By way of an example, we will briefly consider the case of Even. The language has the following vowel system:

(38)	i	(+)	u
	ɪ	(ɪ)	ʊ
	e	ə	ɵ
	a	ɶ	ɔ

There are alternations for all "higher-lower" pairs (/i/-/ɪ/, etc.); the lower series is called *hard*, the higher *soft* (this contrast is also known as masculine/feminine). The hard series is described as involving retraction. In most Tungusic languages the difference co-occurs with a distinction in back velars (uvulars) and plain velars, although front hard, retracted vowels usually fail to condition uvulars.<sup>29</sup>

In the generative literature, the vowel harmony system of the Tungusic language Manchu has received a great deal of attention. There has been an extensive discussion of the treatment of exceptions within the vowel harmony system of this language (Vago 1973; Odden 1978; Finer 1978), who analyze it in terms of a front-back harmony. Hayata (1980) and subsequently Ard (1984), however, argue that the harmony in this language, too, is based on relative height, just as in the other Tungusic languages: retracted versus plain, or high versus low.

Kenstowicz (1983) analyzes the harmony system of Chukchee in terms of [RTR] spreading. The same approach has been pursued for Nez Perce (Hall and Hall 1980; Anderson and Durand 1988), Coeur d'Alene (Johnson 1975; Doak 1992) and Middle Korean (Kim 1978).

Consider the VH systems of the first two languages:

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- (39) (a) Chukchee
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|  | high  |      | non-high |      |
|  | front | back | front    | back |
|  | i     | u    |          | o    |
|  | æ     |      | a        |      |
- (b) Nez Perce
- |  |       |      |          |      |
|--|-------|------|----------|------|
|  | high  |      | non-high |      |
|  | front | back | front    | back |
|  | i     | i u  |          | ə o  |
|  | e     |      | a        |      |

In (39a) /æ/ and /a/ form a harmonic pair and /i/ is unpaired, i.e., it is neutral. In (39b), the vowel /e/ is phonologically a member of the high set, whereas /o/ is the lower harmonic counterpart of /u/ and is part of the low set.

Mongolian languages have often been analyzed as having palatal harmony, but Svantesson (1985) argues that at least the eastern branch (Khalkha, Chakhar, Buriat, Bargha) have vowel harmony based on pharyngeal width. He refers to this as [ATR]-harmony. Rialland and Djamouri (1984) propose that [-ATR] is the spreading value in Khalkha Mongolian. This means that, in the terms used here, Khalkha has [RTR] harmony.

As in the case of Yoruba, these systems could also be classified as [low] harmony systems. That is, in a feature system using [low], with a somewhat broader interpretation than in Chomsky and Halle (1968) of [+low] values (i.e., including (lower) mid vowels), one might classify [RTR] harmony systems which do not involve a retracted set for high *and* mid vowels among the systems based on aperture.

### 2.3 [high]

In this section we discuss a number of harmony systems that have been described as involving the *aperture* dimension of vowels in a particular domain, more specifically involving the spreading of [high].

Consider first the case of Kinande (Clements 1991), which has seven underlying vowels. Vowels *raise* one degree before the stem vowels /i u/. Mid vowels raise to an intermediate level:

- (40)
- |       |       |
|-------|-------|
| → i   | u ←   |
| ↑ i   | u ↓   |
| → [e] | [o] ← |
| ↑ e   | o ↓   |
- a

The low vowel does not raise, but appears to be transparent, although Hyman (1989) points out that *long* low vowels do undergo the rule. Even though this system has been described as involving raising, the traditional feature [high] is not adequate, since the raised version of /ɛ/ and /ɔ/ is not a high vowel.

Schlindwein (1987), Hyman (1989), and Mutaka (1991) analyze this system with a rule that spreads [ATR], which is clearly a possible analysis. There are a number of systems for which an analysis in terms of [high] spreading is more strongly supported. McCarthy (1984) claims that aperture harmony in Pasiego is manifested in two ways, depending on the aperture of the stressed vowel, which is the trigger. The low vowel is transparent.

- (41) (a)  $i/u \rightarrow e/o$  %... (a)... é/ó (lowering)  
 (b)  $e/o \rightarrow i/u$  %... (a)... i/u (raising)

Leftward raising is also triggered by a /j/ or /w/ occurring as a prenuclear vowel in a stressed syllable. The two-way nature of this harmony process has been used as an argument in favor of the binary status of the feature [high], and as an argument to analyze harmony as a feature-changing process. In the analysis of McCarthy (1984), Pasiego harmony is analyzed as a rule spreading [αhigh] bidirectionally.

Vago (1988) argues that lowering is not a rule of Pasiego, however, because there is little evidence for a rule that lowers vowels that can be shown to be underlyingly high. On the other hand, the raising aspect of the analysis is well founded. The importance of this finding is that harmony need not be analyzed as a feature-changing process. Nor do we need a binary feature [±high]. The facts are compatible with an analysis which specifies morphemes as either [high] or leaves them unspecified (see chap. 4, this volume, as well). The feature [high] links to the stressed vowel and then spreads bidirectionally to unstressed targets. The default is to leave vowels non-high. Glides are also specified as high. They spread only leftwardly because on their right there is a stressed vowel, i.e., a non-target.

An analysis of vowel harmony in the Apulian dialect of Francavilla-Fontana (Southern Italy) as involving [high] spreading is offered in Calabrese (1986) and Sluyters (1988). However, even for these cases an analysis can be maintained in which the spreading feature is [ATR] (Durand 1991), if /e/ and /o/ are regarded as the [RTR] counterparts of /i/ and /u/, respectively.

However, not all harmony systems that have been analyzed as aperture harmony systems are susceptible to a reanalysis in terms of advanced tongue root. The clearest case comes from Sesotho (Harris 1987). As in Kinande, mid vowels raise, but in Sesotho the trigger can be any high vowel, i.e., /i u u/.<sup>30</sup>

The interest of the Sesotho raising rule is that it is difficult to see how this rule could involve just [ATR] in view of the fact that all high vowels trigger it. Hence this looks like evidence for spreading an aperture feature. Again, however, the spreading feature cannot be [+high] in the traditional sense,

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## 2.4 [i]

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because the raised output of the lower mid vowels do not become high themselves. An analysis based on aperture which does not use traditional features [high] and [low] is offered in Clements (1991).

## 2.4 [low]

As pointed out by Clements (1991), Bantu languages vary in having a seven- or a five-vowel (or more complex) system. A seven-vowel system is reconstructed for Proto-Bantu. Five-vowel systems have undergone a merger of the two highest series:

(42)	i	u	ɪ	ʊ
	ɪ	ʊ	e	o
	e	o	a	a

A common pattern of height assimilation is that the first vowel of the stem determines the height of subsequent vowels in the stem and the suffixes.

In Kikuyu, the applied suffix shows the following alternations:

(43)	tiY-ir-a	“stop for”	ker-er-a	“chop for”
	rut-ir-a	“work for”	ror-er-a	“look at”
	ruh-ir-a	“pay for someone else”		
	kum-ir-a	“rebuke for”		
	Yamb-ir-a	“bark at”		

In five-vowel languages, the same alternations are found. Suffixes may also show an /ʊ/-/o/ alternation, which in Kikuyu happens only after /o/, though in other languages (e.g., Kongo), it is also triggered by /e/. Clements mentions that the harmony is extended to prefixes in a few languages (Gusii, Llogoori). Round vowels are more resistant to this process, but in Kikuyu they participate if they share their roundness with the trigger.

This lowering can be interpreted as the spread of the feature [low], which forces us to explain formally why the low vowel /a/ does not trigger the process. The low vowel is also opaque, in the sense that lowness does not propagate across it.

The question can also be raised how the highest vowels in seven-vowel systems can be excluded as targets. A possibility that comes to mind would be to claim that the component [low] cannot spread to the highest vowels because this would lead to an incompatible combination of components (in the relevant language). For instance, if we say that the highest vowels are [ATR], we could assume that the combination [ATR, low] is excluded.

### 2.5 Mixed Systems

In some languages we encounter a three-way alternation as a result of [ATR] and [low] spreading, e.g., Klao (Kru) (Singler 1983) and Togo-remnant languages (Ford 1973). Van der Hulst, Mous, and Smith (1986) present an analysis of the latter group of languages, and argue that the three-way alternation is caused by a mixture of two harmonies, one presumably involving [ATR], the other [low].

Most of these languages have a seven-vowel system. In Santrokofi, for example, the following alternations occur:

(44) affix	i	e	ɛ
	u	o	ɔ
-----			
stem	i u	e o	ɛ ɔ a

Apparently the suffix vowels undergo [ATR]-spreading (from /i u e o/) and [low]-spreading (from /e ɔ a/).

### 2.6 Palatal Harmony

In palatal harmony systems, vowels which form harmonic pairs differ in relative frontness. Depending on the vowel system, the vowels which form such pairs may differ just in their value for the harmonic feature (as in (45a)), or also in their value for another feature, if this is predictable on the basis of the value of the harmonic feature (as in (45b)):

(45) (a)	front		back		
	non-round	round	non-round	round	
	i	ü	i	u	high
	e	ö	ə	o	mid
	æ		a		low
(b)	front		back		
	non-round	round	non-round	round	
	i			u	high
	e			o	mid
	æ		a		low

In a system such as (45b) /i/ and /u/ form a harmonic pair; however, they differ with respect to two features, and one might wish to argue that the harmonic feature could just as well be [round]. The low vowel pair /æ/: /a/, however, shows that the relevant difference between the two sets involves backness and that for non-low vowels roundness is redundant. Palatal systems

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in which /i:/u/ and /e:/o/ form pairs are rare. It is more usual that vowels which form a harmonic pair differ *only* in the harmonic feature, as in (45a). The system of (45b) is relevant for vowel harmony in Chamorro (Topping 1968; Poser 1982).

Palatal harmony also occurs in Caucasian languages: Hinalug (Dressler 1985) and Bezhta (also Caucasian, more specifically North East, belonging to the group of Daghestan languages).<sup>31</sup>

(46)	i	ü	u
	e	ö	o
		ä	a

Harmony affects vowels and coronal consonants (but not /t/ and /l/), which alternate between a non-palatal and palatal form:

(47)	I	a o u i	s z c c'
	II	ä ö ü i (e)	S Z C C' and two emphatic laryngeals

It was pointed out above that in many harmony systems, not every vowel will have a harmonic counterpart. Recall the case of Finnish, which has the vowel system in (48):

(48)	front		back		
	non-round	round	non-round	round	
	i	ü		u	high
	e	ö		o	mid
	æ		a		low

The front vowels /i/ and /e/ do not have a harmonic counterpart. We have referred to such vowels as *neutral*. They are typically the result of phoneme mergers in the inventory. The important question of how neutral vowels behave in harmony systems has been discussed above. A peculiarity of Finnish is that transparency has also been reported for the non-neutral vowels /ü/ and /ö/ (Campbell 1980; Demirdache 1988).

Many Turkic languages have the following system:

(49) Turkic palatal harmony:

	front		back		
	non-round	round	non-round	round	
	i	ü	ɨ	u	high
	e	ö	ə	o	non-high

Palatal systems are usually analyzed with [-back], or [front] as the active value. Some researchers, however, have argued that [+back] can also be the active value. Probably the most challenging case to a unary approach to

palatality harmony is the Estonian VH system (Kiparsky 1992). Farkas and Beddor (1987) argue in favor of an active [+back] value in Hungarian.

## 2.7 Labial Harmony

In labial harmony, harmonic pairs differ in having or not having lip rounding as a distinctive feature. This involves the feature [ $\pm$ round]. In principle, a vowel system such as that in (50) can be divided into a set of [+round] vowels and a set of [-round] ones:

(50)	round		non-round		
	front	back	front	back	
	ü	u	i	ɨ	high
	ö	o	e	ə	mid
		ɔ		a	low

Many Turkic languages have a two-height eight-vowel system, showing both palatal harmony (cf. (49) above) and labial harmony:

(51) Turkic labial harmony:

	round		non-round		
	front	back	front	back	
	ü	u	i	ɨ	high
	ö	o	e	a	non-high

In the Turkish system /e/ and /a/ do not function as the harmonic counterparts of / $\ddot{o}$ / and /o/, however, so that labial harmony effectively applies to high vowels only (see also n. 6 for this type of "contextual neutralization").

Labial harmony systems may be reduced in various ways. Korn (1969) provides some information on different patterns of reduction in labial harmony in Turkic languages.

A topic of special interest concerns *parasitic harmony* (Steriade 1981; Cole and Trigo 1988; Odden 1991). There are cases in which labial harmony is restricted to words the vowels of which are all front as a result of palatal harmony. The vowel harmony system of Kirghiz (C. Johnson 1980) is a case in point. The vowel system is as in Turkish, and suffixes have either a high or a low vowel. Suffixes have four variants, as shown below:

(52)	bil-di	bil-gen	bil-üü	"know"
	ber-di	ber-gen	ber-üü	"give"
	kül-dü	kül-gön	kül-üü	"laugh"
	kör-dü	kör-gön	kör-üü	"see"
	kil-di	kil-gan	kil-uu	"do, perform"

al-di  
tut-t  
bol-d

Unlike Turl difference is labial harm back vowel: Kirghiz hi the same as of /o/ in ne intrinsic rou vowel is the explanation ( rounding. In namely [fron harmony is f

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(53) non-round  
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Suffixes contain stem vowel if ti number of forme height-agreemen the feature [rou

al-di	al-gan	al-uu	"take"
tut-tu	tut-kan	tut-uu	"hold"
bol-du	bol-gon	bol-uu	"be, become"

Unlike Turkish, Kirghiz has suffixes which are intrinsically round. A further difference is that /I/ and /A/ (which are not intrinsically round) *both* undergo labial harmony with one notable exception: /A/ is not rounded after a high back vowel: *tut-kan* instead of *tut-kon*.

Kirghiz has a labial harmony rule, then, which fails to produce /o/. This is the same as in Turkish, but in this case it cannot be attributed to the absence of /o/ in non-initial syllables, since low rounded suffixes do exist (i.e., with intrinsic rounding).<sup>32</sup> Why the sequence of a high followed by a non-high vowel is the most likely to have rounding harmony awaits a theoretical explanation (see Odden 1991 for discussion). Low vowels are more resistant to rounding. In a front domain, a high low sequence already shares a feature, namely [front], which facilitates the harmony. In a sequence of two low vowels, harmony is facilitated by the fact that the vowels are already identical.

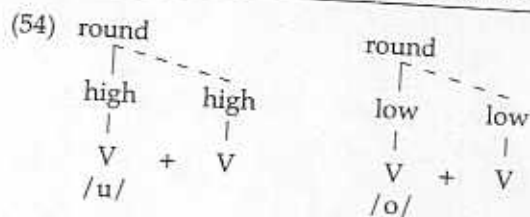
Labial harmony is widespread in Uralic languages (see, e.g., Collinder 1960; Finnish, Hungarian, and Cheremis are well-known examples) and in Altaic languages (with examples from all well-known families, Turkic, Tungusic, and Mongolian). We wish to observe that in most cases labial harmony co-occurs with another type of harmony, and that the labial harmony is more restricted in these cases (see Vago 1973 for a general discussion). This was the case in the Turkic systems that we have just discussed. It also applies to the Tungusic languages, where labial harmony co-occurs with tongue root harmony and is generally restricted to the low-vowel region. An extremely limited form of labial harmony co-occurring with palatal harmony occurs in Hungarian (see, e.g., van der Hulst 1985).

In the African languages Chumburung (Snider 1990) and Igbo (Battistella 1980) labial harmony also occurs, in both cases together with ATR-harmony. Archangeli (1985) discusses one of the few cases of labial harmony where it occurs without another system of vowel harmony, namely in a number of Yokuts dialects. These cases, especially that of the Yawelmani dialect, have received a great deal of discussion in the literature.

The vowel system of Yawelmani is as follows:

(53) non-round	round	
i	u	high
a	o	non-high

Suffixes contain a high or a low vowel which agrees in roundness with the last stem vowel if this vowel is of the same height. Archangeli (1985) discusses a number of formal possibilities for dealing with the dependency of harmony on height-agreement, ending up with the proposal that in the formal representation the feature [round] is dependent on the feature [high]:

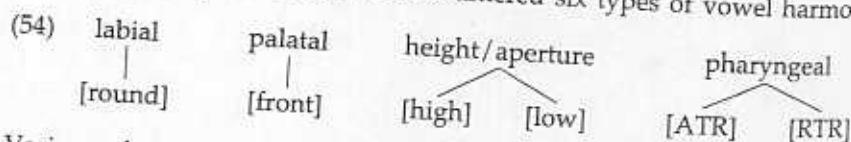


We may assume that the suffixes are not specified lexically for the feature [round]. Given such representations, the type of harmony in Yawelmani Yokuts can be seen as the result of fusing the aperture feature of adjacent vowels if these features are identical. The agreement of other properties is then a result of this fusion. In other words, harmony in Yokuts does *not* apply to labial, but to aperture features, and the process is *not* spreading, but fusion.

## 2.8 Summary and Remaining Issues

### 2.8.1 Summary

In the preceding discussion we encountered six types of vowel harmony:



Various close relations, both synchronic and diachronic, hold among the established harmony types. This might be explained by the way the components involved are organized intrasegmentally (Odden 1991). There are close relations between raising and ATR harmony on the one hand, and lowering and RTR harmony, on the other. In specific cases it is not entirely clear whether a system involves [high] spreading or [ATR] spreading. The same ambiguity applies to the role of the components [low] and [RTR].

Clements (1991) has claimed that there is a single set of *aperture features*, which is the locus of expression of both height and ATR differences. Clements applies his model to a number of harmony systems based on height, and suggests that we need no separate feature [ $\pm$ ATR] for systems which are usually dealt with in terms of this feature. Van der Hulst (1993), like Clements, argues that ATR and height involve the same phonological primitives and differentiates between the two interpretations by arguing that the [ATR] version involves the relevant component in a dependent position, while the height version involves the same component in head position. A similar proposal is made for the pair [RTR] and [low].

We do not want to go beyond highlighting the options and correlations we have just summarized. A proposal for a segment-internal organization of the vowel components is unfortunately beyond the scope of this overview of harmony systems.

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### 2.8.2 "Total Harmony Systems"

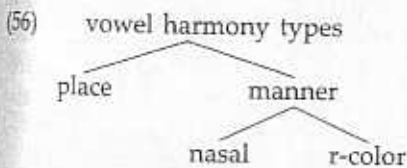
In a number of languages, usually with "simple" triangular vowel systems, there is a kind of vowel harmony which involves the complete copying of a vowel, so that there are alternations between /i/, /a/, and /u/ depending on the context or specific case.

Such harmonies occur in a number of Australian languages (see chap. 25, this volume, and van der Hulst and Smith 1985). In Djingili, for example, /a/s in the stem alternate with /i/ before suffixal /i/s. This leftward "spreading" of /a/ is unbounded. An intervening /u/ blocks spreading. In Warlpiri several harmonies are found. Some suffixes have /i/ after stem /i/, and /u/ elsewhere. This progressive harmony is also unbounded. Other suffixes have /u/ after /u/ and /i/ elsewhere. Finally, there is regressive harmony producing /u/ before /u/ and /i/ elsewhere. A third example is Nyangumarta (Hoard and O'Grady 1976), where suffixes take /i/, /u/, /a/ depending on the last stem vowel. All three languages have a triangular /i a u/ vowel system.

These cases can be separated from the previously discussed cases in that the harmony does not involve a "secondary property alone," like frontness, tongue root position, and labiality. These alternations can often be analyzed by taking one vowel to be a completely unspecified vowel, e.g., the vowel /a/ in Djingili. Total harmony systems are not limited to Australian languages, however. A similar system occurs in the Dravidian language Telugu (Kiparsky 1981).

### 2.8.3 Non-place Harmony

All harmony systems discussed so far, including those in the previous section, involve vowel place properties. There are other vowel harmony cases, however, which either clearly do not involve place or could be argued to involve something different from place. We tentatively propose the following typology:



We exclude here from consideration cases of nasal "spreading" which do not only affect vowels, but rather strings of adjacent sonorant segments (see Piggott 1988 for an extensive study of these cases). The term "r-coloring" is meant to include retroflexion. Retroflex harmony is found in Yurok (see Smith et al. 1988).<sup>33</sup>

It is possible that some harmony systems may also involve a "register" distinction, which may very well refer to a laryngeal property. Trigo (1991) offers a discussion of register and suggests that vowel harmony in Turkana

involves a tense versus lax distinction. Her proposal is that the fundamental register distinction may manifest itself through a laryngeal feature involving laryngeal lowering or raising, or a pharyngeal feature like ATR/RTR. This may imply that vowel harmonies which are interpreted as involving ATR/RTR may be close to or misanalyzed as cases of harmony that involve a laryngeal feature.

### 3 Consonantal Interference

So far the discussion of locality has focused on the fact that consonants are skipped in vowel harmony. This assumes that vowel harmony takes into account all vowels while ignoring all consonants. In this section, we focus on cases of consonantal interference.

The issue of consonantal interference is a difficult one and there is not much systematic research on this topic. We will briefly indicate what kinds of interactions have been reported and refrain from a detailed theoretical discussion. The issue is obviously of great relevance, especially in the context of theories which employ the same set of features for vocalic and consonantal place properties. We discuss three types of consonantal interference: cases in which consonants with secondary articulation have an effect on vowel harmony (sec. 3.1), cases in which vowels have an effect on consonants (an effect in the opposite direction; see sec. 3.2), and cases in which consonants that do not have secondary articulation appear to influence the harmony (sec. 3.3).

#### 3.1 Secondary Articulation

Consonants with secondary articulation can interfere with a harmony system. For example, palatalized consonants can interfere with the harmony system in a language with a palatal harmony system. A case in point is Turkish, where palatalized consonants spread their vocalic specification to suffix vowels (Clements and Sezer 1982):

(57)	infil'ak	infil'a:k'i	"explosion"
	ittifak	ittifa:k'i	"alliance"
	imsak	imsa:k'i	"fasting"
	eml'ak	eml'ak'i	"real estate"

Since palatalized velars do not occur word-finally, the palatalized character of these velars will only show up if a suffix is added.<sup>34</sup>

Such interference can be explained in a geometrical autosegmental phonology

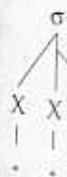
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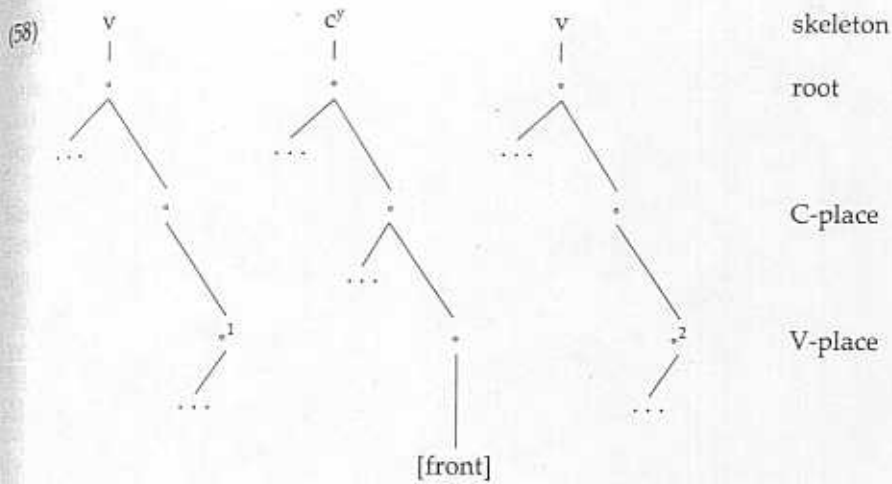
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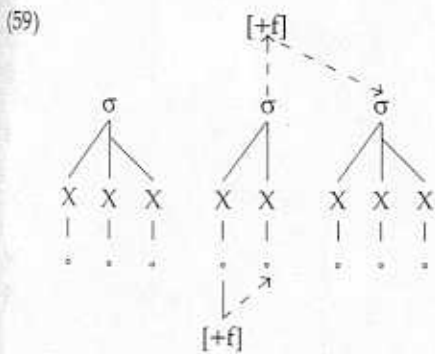


model by assuming that palatalized consonants have the specification [front] under a V-place node:



Indeed, in the geometrical approach it is predicted that consonants with secondary articulation *always* interfere with harmony.

With a syllable head approach to the vowel harmony domain, one is presumably forced to analyze this phenomenon as a secondary, local case of feature spreading, since consonants are not visible on the syllable head tier. In the syllabic approach, then, harmonic interaction between vowels and consonants with a secondary articulation must be stated locally by way of a spreading rule, and consonants are not directly involved in the harmonic relations that hold between syllable heads. The local requirement could be, for example, that vowels adjacent to a palatalized consonant become [front] by local spreading. This feature is then propagated to the syllable nodes and spreads rightward to the suffix vowel, as shown below. The syllable head approach does not *require* vowel harmony to be influenced by consonants with secondary articulation.



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### 3.2 Allophonic Variation

In some languages with a palatal harmony system, front velars are found in words with [-back] vowels, and back velars (or uvulars) appear in words with [+back] vowels. This distinction is usually allophonic.

The harmony system of Bashkir is given in (60):

(60)	high	i	ü		u
	mid	ə	ö	ĩ	o
	low	ä		a	

Bashkir has palatal and labial harmony. The former affects the whole vowel system, but labial harmony is restricted in that it is only triggered by mid vowels, which also constitute the targets. A case in which non-dorsals are affected in a palatal harmony system is that of Bezhta, discussed in section 2.5.

Poppe (1962, p. 22) informs us that the consonants /g k/, in words of Turkic origin, occur only in words of front vowels: /büläk/ "gift", /igän/ "crops". The consonants /G q/ occur only in native words that contain back vowels: /ayaq/ "foot", /GwaGa/ "noise".<sup>35</sup> A similar alternation was mentioned in our discussion of the Tungusic languages, which are claimed to have a tongue root harmony system. The question why a similar alternation occurs in both palatal and tongue root harmony systems suggests a common denominator for both types. In this respect it is interesting to note that Svantesson (1985) makes the claim that both harmony systems are in complementary distribution in the Mongolian language family.

In a geometrical approach to locality, this can be analyzed by stating (in some way or another) that velar consonants are allowed to have a V-place node, which includes them in the class of possible targets of vowel harmony. That is, front velars would be analyzed as palatalized velars and uvulars as non-palatalized velars. Alternatively, if one could make the case that [+back] is the spreading feature, the uvulars would be the consonants which have the secondary articulation. A drawback to this is that the difference between velars and uvulars is perhaps not one that should be expressed in terms of secondary articulation. Such an approach would fail to explain why labials do not participate in a similar fashion in palatal systems and also why velars fail to participate in other types of harmonies, such as labial harmony. We should express somehow that [front] can be used to "subcategorize" dorsals and not coronals or labials (see van der Hulst 1993 for a discussion of this issue).

### 3.3 Primary Place Properties

Consonants without secondary articulation may also have an effect on vowel harmony, and it is useful to divide these into two cases: those where glides are reported to have such an effect and those where "real" consonants do.

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3.3.1 *Glides*

In Turkish the approximant /j/ has an influence on surrounding vowels. It is claimed that to its left, /j/ (as well as palato-alveolar consonants) only allows /i/ or /ɨ/ (the choice depending on the frontness of preceding vowels), while to its right /i/ and /ɨ/ as well as /e/ and /a/ occur (the choice again depending on the harmonic property of the root). In other words, /j/ derounds and raises vowels to its left, while to the right only derounding applies (Kumbaraci 1966).

In Bashkir (Poppe 1962) /w/ is reported to interfere with labial harmony. For example, in Bashkir /w/ blocks rounding just as the high vowels do: /qrowli/ "loaded (of a rifle)". The final /i/ is not rounded due to the interfering /w/ (cf. Poppe 1962, p. 20). In Turkana, vowels preceding semivowels are predictably [ATR] (Dimmendaal 1983).

One might argue that these approximants are like the vowels /i/ and /u/ as far as their feature content is concerned, but they are not in the syllable head position and therefore are not expected to participate in the harmony. Such cases, then, raise problems for a syllable head approach and seem to indicate that segments in non-head position can directly interfere with the harmony if they are vowels as far as content is concerned, which is what approximants arguably are.

## 3.3.2 "Real" Consonants

There are several cases in which non-approximant consonants interfere with vowel harmony, either by imposing a value on neighboring vowels or by blocking the interaction between vowels.

In a number of cases, labial consonants impose their roundness on neighboring vowels. For example, in Warlpiri labial consonants require a following vowel to be /u/ (Nash 1979; van der Hulst and Smith 1985). Another well-known case is "labial attraction" in Turkish (Clements and Sezer 1982; van der Hulst and van de Weijer 1991). In the literature on vowel harmony in Turkish, special status is sometimes assigned to the pattern /a C<sup>w</sup> u/, in which C<sup>w</sup> is a labial consonant. The unexpected rounding of the non-initial high vowel is attributed to the preceding labial consonant. However, Clements and Sezer (1982) show that the pattern /a - u/ also frequently occurs when the consonant is non-labial (61a), while on the other hand the pattern /a C<sup>w</sup> ɨ/ (61b) can also easily be found:

(61) (a)	marul	"lettuce"	(b)	sabır	"patience"
	fatura	"invoice"		kapı	"door"
	yakut	"emerald"		kamış	"reed"

We conclude that "labial attraction" does not form part of the synchronic phonology of Turkish.

In Finnish, velar consonants may prevent frontness from spreading so that

vowels following the velars end up being back. Some examples of this are given in (62), from Kiparsky (1981).

- (62) itikka "mosquito"  
 etikka "vinegar"  
 tiirikka "lock pick"

In section 3.2 we saw that velar consonants can vary between (front) velars and uvulars, depending on the harmonic class to which the word they occur in belongs. This is reported for palatal systems. In Coeur d'Alene (Johnson 1975; Doak 1992) a class of "faucal" consonants (articulated with tongue root retraction) cause vowels to their right to lower. In many Semitic languages, lowering influences from "back consonants" (i.e., gutturals) are reported as well (cf. McCarthy 1991). Whether such cases belong in this section or in section 3.1 depends on one's analysis of back consonants such as uvulars and pharyngeals. We will not enter into this issue here.

As discussed in section 3.3.1, cases where consonants interfere with harmony are an embarrassment to the syllable head approach. It is, on the other hand, also fair to say that vowel-consonant interactions form an ill-understood area. Cases where such interaction takes place have been used to argue that features for representing place in consonants and vowels are partly the same, but precisely under what circumstances vowels harmonize with consonants is not clear, and, in any event, such harmony appears to be local in all cases, i.e., where a consonant interferes there is never evidence that a new harmonic span starts.

#### 4 Conclusion

We have presented a brief overview of what are, in our opinion, the major types of vowel harmony systems. Vowel harmony has always been a challenging area of research for developing theories of segmental structure. There is no reason to believe that this will change in the near future.

The previous sections have also made clear that our knowledge of the structure and classification of harmony systems is still extremely limited. The phonological community will benefit from an extension of the set of well-documented cases and analyses. We hope that this overview will be an impetus for further theoretical and descriptive work.

#### NOTES

1 Previous cross-linguistic studies of vowel harmony appear in Greenberg

(1963), Aoki (1968), Ultan (1973) and L. Anderson (1975).

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General introductions appear in Vago (1980b); see especially S. Anderson's contribution to that volume (S. Anderson 1980). Influential early treatments include Stewart (1967), Clements (1976), Halle and Vergnaud (1981), and formal aspects are highlighted in Vergnaud (1980) and Tohsaku (1983).

- 2 No claim is made here as to which phonological feature is used to make the distinction; we will return to VH systems like that of Tangale in section 3.
- 3 In the literature one can find empirical, descriptive, and theoretical reasons for making a distinction between stem-internal vowel harmony and harmony between stem and affixes. A descriptive distinction is found in Clements and Sezer (1982), who claim that vowel harmony in Turkish is active in stem-affix combinations, but no longer in polysyllabic stems. In the traditional generative literature stem-internal harmony and harmony between stem and affixes was often treated by means of separate rules (viz., morpheme structure rule and P-rule; cf. Kenstowicz and Kisseberth 1977, pp. 136-145 for a discussion of such treatments).
- 4 Dominant VH systems have also been referred to as asymmetric, and stem-controlled systems have been referred to as symmetric. This is merely a terminological issue.
- 5 Kidda (1985, pp. 143, n. 4) states that *-na* is the only suffix containing the vowel /a/.
- 6 Neutral vowels are also called invariant. There are in fact three sources for invariance. First, vowels may be *absolutely neutral*, such as /a/ in Tangale. Second, vowels may be invariant in certain positions of the word, such as non-initial position. We refer to this as *contextual neutralization* (as in Turkish, see sec. 2.6). Finally, vowels may be invariant in particular lexical items, whether stems or affixes: these are cases of lexical (or exceptional) neutralization. Van der Hulst and Smith claim that all invariant vowels are subject to the generalization that they propose.
- 7 Transparency effects in disharmonic stems are also found in Finnish; see Campbell (1980), Steriade (1987).
- 8 We thank Krisztina Polgárdi for help with these examples.
- 9 This is the only exception; otherwise the suffix is invariably *-us*.
- 10 This is the case in Tangale; see Kidda (1985, p. 133).
- 11 Levergood (1984) argues that vowel harmony in Maasai is subject to cyclicity.
- 12 Umlaut as we find it in the early stages of Germanic languages, where the stressed vowel harmonizes with vowel endings, has also been analyzed as foot-based vowel harmony (cf. McCormick 1981; Hamans 1985). The term *metaphony* has been used for such cases (see S. Anderson 1980, p. 3 for discussion).
- 13 Reference has also been made to an even larger domain; this is the case of Somali (Armstrong 1934; Hall and Hall 1980).
- 14 Which value is filled in may furthermore depend on the phonological context. For instance, it might be claimed that in front vowels [+round] is a marked and therefore specified feature value, and in back vowels the same goes for [-round].
- 15 A further claim is that languages may override the universal

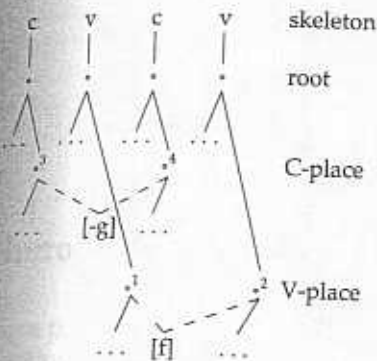
- markedness relations and treat the unmarked value as the lexically present value. In those cases the unmarked value effectively functions as a default value. Moreover, both values may be active from the start, namely if both function in statements of morpheme structure conditions.
- 16 In dominant systems (see sec. 2.1.2), morphemes that do not change provide a clear indication what the default value is.
- 17 An alternative is to postulate a "floating" feature [+back]. Not all neutral vowel roots behave like *hid*, but this does not alter the point.
- 18 In some theories it is claimed that some features are binary, whereas others are unary. The distinction between binary and unary primes is sometimes referred to as a distinction between *equipollent* and *privative* features (cf. Goldsmith 1985, p. 254).
- 19 In practice, however, theories will differ from each other in other respects as well, most notably in terms of which phonological primes are adopted, and whether they incorporate structural notions such as intrasegmental feature grouping and dependency relations. As a result, it may not always be straightforward to establish how different theories differ in the predictions they make.
- 20 A point that complicates this discussion is that a unarist might argue that there are two unary features, [front] and [back], or [round] and [spread] to replace any binary feature. What this point reveals is that the set of features adopted in a theory should not have the status of a random list. In other words, a feature theory is only meaningful if it can be shown that the proposed set of features is *closed*. See van der Hulst (1993) for a defence of the set we use here.
- 21 This approach is identical in spirit to the Prosodic School analysis of vowel harmony (see Firth 1948; Palmer 1970; Goldsmith 1976).
- 22 We discuss consonants that have a secondary articulation in section 3.1. Such consonants have a class node to which vowel features associate, and are therefore expected to interfere with vowel harmony.
- 23 The question whether the sets of place features for consonants and vowels are distinct or the same is separate and irrelevant here (see chap. 7, this volume). The crucial point is that vowels have a class node which consonants lack.
- 24 In a model that adopts underspecification, a situation may arise in which a particular vowel has no features at all in its underlying representation, in which case such a vowel will presumably also lack a V-place node. This adds a technical complication to the class-node definition of the notion harmonic unit. We must say that a unit is harmonic (with respect to some harmonic feature) if it (a) has the class node to which the harmonic feature can associate or (b) *can* have that class node in the language at stake. Somehow, then, it must be possible to recognise a vowel as being able to have a V-place node, even if it lacks all vowel features. This identification will presumably have to rely on an inspection of the syllabic position of the relevant skeletal point, which shows that the skeletal tier must be inspected even for processes that are not strictly local (also for the OCP).
- 25 In some versions of autosegmental phonology it has been proposed that the segmental properties of

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vowels and consonants appear on entirely separate planes. This would explain why consonants do not intervene in vowel harmony, but it would allow consonant harmony just as easily:



In this representation the association of [-g] to nodes 3 and 4 is also local, which it would not be if the intervening vowel had a C-place node. Another approach could be to make use of planar segregation, i.e., to arrange consonant and vowel features on independent planes. However, this kind of segregation should be restricted to the level of lexical representation.

26 The question whether there are solid cases of feature sharing between class nodes of nonadjacent consonants will not be dealt with here (see Poser 1982 and Shaw 1991 for examples). It is consistent with the above that such non-local relations will involve properties which are never distinctive for vowels, such as manner features (with the exception of [nasal]). Sibilant harmony is a case in point. Hence, it is not an ad hoc move to claim that vowels do not participate in sibilant harmony because, since there are no contrasts in sibilancy between vowels, they have no node

to which the relevant features could attach. Finally, within declarative approaches to phonology (e.g., Scobbie 1991), it has been claimed on formal grounds that all feature sharing must be local. Hence, in such a view, vowel harmony cannot involve local assimilation.

- 27 Or in terms of their binary equivalents, [+ATR]/[-ATR], [+RTR]/[-RTR] and [+high]/[-high], [+low]/[-low].
- 28 See Stewart (1971) on the related language Anyi-Bawuke.
- 29 The descriptions of Even vary somewhat. Comrie (1981) gives,

(i)	i	u		
	ɪ	ʊ		
	ie	e	ə	o
	ɪa	a	ɚ	ɔ

i.e., he adds two diphthongs.

- 30 According to Clements, the vowels /e o/ are not only derived by raising but occur also underlyingly. There is a further process of raising affecting /i/ and /u/ in the context of /i/ and /u/. This rule does not affect underived /e/ and /o/.
- 31 Mongolian has also been analyzed as a kind of palatal harmony system.
- 32 Hungarian has a reduced system of rounding harmony, which affects suffixes with short /e/. There are three types of suffixes with mid short vowels:

- (a) ɛ-a (e.g., nek/nak)
- (b) ɛ-o-ö (e.g., hez/hoz/höz)
- (c) ɛ-a-o-ö (e.g., el/ak/ok/ök)

We also find labial harmony co-occurring with the RTR harmonies in Mongolian and Tungusic languages.

- 33 Tone spreading can be seen as a

form of harmony, especially when this involves tone affixes which harmonize with stems. No cases of stem-internal tonal harmony are known to us. Hence, formally speaking, stems tend to be tonally disharmonic.

- 34 In a dialect of Akan, palatalized consonants have an effect within a relative-height harmony system (see Boadi 1963).
- 35 This kind of consonant harmony is also reported for Kirghiz (Johnson 1980).

## 15 Syntax

SHARON

### 0 Introduction

How are the syntactic and phonological processes related with respect to the interface? This article is concerned with the interface between syntax and phonology. It is argued that they exert mutual influence. The interface has a solid empirical basis (recent collections including Johnson 1980). The primary source of evidence for the interface is over syntactically defined domains. The dependent (syntax) is related to the independent (phonology) in interactions between the two domains in opposite directions: cross-domain interactions and within-domain interactions. In this article, we review the evidence for different facets of syntactic influence on phonology and the influence of the phonology on syntax as a basis for proposing a general account of the interface for this kind of interaction. The article is organized into three rule domains: general constraints, respectively specific constraints, and evidence that phonology influences syntax. Probable directions of influence are presented in section 1.

### 1 The Nature of the Interface

Evidence for the syntactic influence on the phonology of the functioning of F