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The Geometry of Vocalic Features

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0. INTRODUCTION

Recent years have shown an increased interest in simplex or *single-valued phonological features*; for an early statement, cf. Sanders (1972). In my view, a single-valued feature system represents the logical end point of what is called *Radical Underspecification* (Kiparsky 1982, Archangeli 1984, 1988). The central goal is to express that the two members of a binary opposition do not play the same role in the phonology. Radical Underspecification Theory expresses this by using binary features, while stating that only one value may be specified in the underlying representations; the other value, often called the *default value*, is added during or at the end of the derivation. In a single-valued approach a stronger claim is made. The default value is eliminated as a phonological entity altogether, so that the feature is single-valued at all stages of the phonological derivation. Current single-valued theories are also stronger than current underspecification theories in another respect: in a single-valued theory it is always the same member of the opposition that represents the marked phonological property. Underspecification approaches allow the possibility that either of the two values of any feature is marked.

In this article I propose a particular single-valued feature system for vowels, which differs from other current single-valued systems, although it shares fundamental insights with some of them. In section 1, I will outline the model and concentrate on providing typological and phonetic justification. In sections 2 and 3 I will turn to the phonological argumentation and suggest how the system can be put to use in the analysis of vowel harmony processes, and in section 4 I offer a discussion of some potential arguments against a single-valued system. Section 5 addresses the issue of *transparency* and *opacity* in harmony systems.

1. THE PROPOSAL: A SINGLE-VALUED FEATURE SYSTEM FOR VOWELS

My proposal can be seen as a development of *Dependency Phonology* (DP, cf. Anderson & Ewen 1987) and *Government-based Phonology* (GBP, cf. Kaye, Lowenstamm & Vergnaud 1985) and much work inspired by (aspects of) these approaches (e.g. Schane 1984, Goldsmith 1985, 1987, Rennison 1986, 1987a, 1987b, Van der Hulst & Smith 1985, 1986a). For brief summaries of both DP and GBP and a comparison to the present proposal I refer to Van der Hulst (1987, forthc. a, b). For a more extensive and somewhat critical discussion of these approaches, as well as of binary underspecification approaches, I refer to Den Dikken & Van der Hulst (1988).

The argumentation in favour of the single-valued feature system is complex, depending on a variety of empirical and conceptual considerations. By way of introduction, let me draw attention to the fact that studies of typological surveys of phonological systems, e.g. those of Crothers (1978) or Maddieson (1984), reveal that, in general, there are more oppositions amongst high vowels than amongst low vowels, so that languages having two low vowels differing only in the front-back dimension, and not in length, are typologically marked. A feature system such as that of SPE, however, treats the vowel space as basically *rectangular*, as in (1):

(1)		[–back]	[+back]	
	[+high]	/i/	/u/	[–low]
	[–high]	/e/	/o/	[–low]
	[–high]	/æ/	/ɔ/	[+low]

On the basis of typological considerations, however, we would prefer rather to have a feature system which characterizes vowel systems as basically *triangular* (cf. Fisher-Jørgensen 1984a,b and Basbøll 1984 for a discussion of these matters). We can do this, following DP and GBP, by assuming a different feature system which takes the three points of the vowel triangle as primitives. This gives us three features, which will be represented in terms of the letters | i |, | u | and | a | between vertical strokes, as in DP. A simple three vowel system consisting of [i], [u] and [a] can now be represented in the following way:

(2)	/i/	/a/	/u/
	| i |	| a |	| u |

In DP the term *component* is used, instead of feature, and in GBP the primitives are referred to as *elements*. Here, I ignore potential substantial issues which are involved in the choice of terminology, and continue to use the term *single-valued* or *unary* feature. (Instead of single-valued, others have used terms like *simplex* (Sanders 1972), *monovalent* (Archangeli 1988) or *singulary* (Chafe 1970) in the same sense.)

Not all vowel systems have the form in (2), of course. Vowel systems may include, for example, mid vowels, front rounded, back unrounded, central vowels, advanced vs. retracted vowels, etc. Within the present approach, and again I share this with DP and GBP, additional vowels are represented by combinations of the three features. For example, mid front vowels can be represented as combinations of the features | i | and | a |.

But vowel systems can contain more than one mid front vowel. Assuming that we want to characterize all of them as combinations of | i | and | a |, we then need some way of stating the difference. This is where the *dependency* or *government relation* comes in. A characteristic feature of the present approach, also shared with both DP and GBP, is that the features which make up the content of segments are organized in terms of an asymmetrical relation indicating, in intuitive terms, which of them represents the more salient property. Hence, given that we have two features | i | and | a |, there are two possible feature structures:

```
(3)   a.  /e/        b.  /ɛ/
          i              a        (governor)
          |              |
          a              i        (dependent)
```

Using representations as in (3) raises the question how we interpret them phonetically and how we can actually tell that combining | i | and | a | gives us a front mid unrounded vowel rather than a voiceless lateral velar fricative. This is where the *phonetic interpretation* of the features becomes relevant.

In my approach the status of each feature as either governor or dependent is reflected by a distinct phonetic interpretation, corresponding to what would be a separate phonological feature in feature systems which do not make use of the government-dependency relation (henceforth G-relation). The interpretation I propose for | u | is the following:

```
(4)   Interpretation of  | u |
      Governor:             Velar constriction
                                   |
      Dependent:                Rounding
```

These two aspects of | u | correspond to different articulatory gestures which naturally go together in the sense that lip-rounding *enhances* the acoustic effect of velar constriction (cf. Stevens, Keyser & Kawasaki 1987). It is, therefore, far from arbitrary to give formal expression to the intimate relation between roundness and backness in the way proposed here; although different from an articulatory point of view, they are the same in acoustic terms. I would like to go further and state that it must be deducible from any theory of features that the features [velar] (or [back]) and [labial] (or [round]) are intimately related.

What I propose here reflects the same idea that has prompted our choice for the single-valuedness of features in the first place, viz. the idea that *markedness considerations* should be expressed directly in the primitives and principles of the theory. The use of single-valued features represents an attempt to deduce markedness from the basic structure of the theory. However, markedness not only involves the "context-free" phenomenon that one value of every feature is marked, it also involves "context-dependent" phenomena such as the fact that backness and roundness tend to go together. The present proposal, then, represents an attempt to render superfluous two types of SPE "markedness rules" by building their content directly into the phonological formalism. In (5), the first rule type is replaced by the claim that features are single-valued, while the second type is replaced by the dual interpretation of the phonological primitives:

(5) a. [Uround] → [–round]
b. [Uround] → [αround] / [– , αback]

The advantage we gain is that the "content" of the expressions in (5) is no longer arbitrary from the perspective of our theory.

For the features | i | and | a |, I suggest the following dual status:

$$\begin{array}{llll} (6) & \text{a. } \textit{Interpretation of } |i| & & \text{b. } \textit{Interpretation of } |a| \\ & \text{G: Palatal constriction} & & \text{G: Pharyngeal constriction} \\ & \qquad\quad | & & \qquad\qquad | \\ & \text{D: Advanced tongue root} & & \text{D: Openness} \end{array}$$

Can we justify the grouping of properties in these cases, too? We know that palatal constriction results from advancing the tongue root, as indicated for example in the studies of Wood (1982). It is therefore not arbitrary to suggest that [Advanced tongue root] is closely linked to [Palatal constriction]. Similarly, it is also clear that a-type vowels (i.e. vowels produced with pharyngeal constriction) are produced with a jaw opening which is wider than that for u-type vowels, thus showing that jaw opening and pharyngeal constriction tend to cooccur as well.

The use of | i |, | u | and | a |, instead of the SPE features in (1), with their interpretation as linguistically relevant constriction locations, ties in rather well with findings and proposals regarding vowel systems, presented in Wood (1982), who shows in some detail that the traditional tongue arch model in which vowels are characterized according to the location of the highest point of the tongue simply cannot be maintained in the light of X-ray recordings of actual vowel production. Wood's feature system is briefly discussed in Van der Hulst (1987, forthc. a).

The typological and phonetic considerations just mentioned seem to suggest an initial plausibility for the proposal under consideration, but are not intended as a substitute for phonological justification, which will be supplied in the following sections. Let us first look, however, at some further aspects of the model. Consider the representations in (7) of simple three or five vowel systems:

$$\begin{array}{lccccccccc} (7) & \text{a.} & /i/ & /u/ & /a/ & \text{b.} & /i/ & /e/ & /u/ & /o/ & /a/ \\ & & i & u & a & & i & i & u & u & a \\ & & & & & & & | & & | & \\ & & & & & & & a & & a & \end{array}$$

I will adopt a universal redundancy rule which assigns a dependent feature identical to the governor, unless its absence is distinctive in the system. In this way I account for the fact that, for example, a back vowel is naturally rounded:

(8) *Universal Redundancy Rule*:

$$\begin{array}{ccc} f & \rightarrow & f \\ & & | \\ & & f \end{array}$$

Furthermore, I assume that the phonetic interpretation of features is absolute, in the sense of non-gradual. From this it follows that a single feature can occur at most twice in the representation of a single segment, once as a governor and once as a dependent; there is no point in stating twice that a segment is rounded. This means that for any pair of features we can generate maximally 8 feature structures; take |i| and |a| as an example:

$$\begin{array}{lcccccccc} (9) & i & i & i & i & a & a & a & a \\ & | & & | & | & | & | & & | \\ & i & & a,i & a & i & a,i & & a \end{array}$$

I also assume that the phonological representation of a particular segment is, in part at least, system-dependent. For example, the way in which a particular mid front unrounded vowel is represented in a given system will depend on its phonological behaviour and on the overall structure of the vowel system. Thus, I will allow an e-type vowel to be represented in terms of different structures, e.g.:

(10) a. i b. i c. i
| |
a,i a

We will see various examples of the many-to-one relations between feature structures and segments. On this basis, I conclude that this flexibility, although perhaps suspect at first sight, is actually necessary.

It is perhaps the case that we allow more combinations of two features than are allowed in DP (cf. on this Den Dikken & Van der Hulst 1988) and in any event we allow more than are allowed in GBP, because every feature can occur twice in the representation of a single segment. The total number of potential contrasts is not disturbingly great, even though we do generate more contrasts than any individual language will allow at the level of lexically distinctive segments. This is not the kind of expressive power one is after, but I see no way of avoiding it completely.

In this system, there is no need for an independent feature [ATR], since ATR is identified with the feature |i| in dependent position. I stress this, because both DP and GBP have a separate feature [ATR]. Also, DP and GBP use a fifth component (i.e. |ə| "centrality") or element (i.e. [v], the so-called "cold vowel"), which plays an essential role in the characterization of central and back unrounded vowels. In the present proposal we can characterize central and back unrounded vowels without the use of extra features. Consider the following representations:

(11) a. /ɯ/ /u/ b. /i/ /ɨ/
u u i i
| |
u i

Given the phonetic interpretation of our features, (11a) represents the distinction between a back unrounded and a back rounded vowel. The feature specifications in (11b) represent a distinction between an advanced high front vowel and its non-advanced or slightly less fronted counterpart. It seems to me that these are the kinds of distinctions we can use for systems having central or back unrounded vowels.

One could object to the representations in (11), saying that rounded back vowels are formally more complex than their unrounded counterparts, whereas they are less marked typologically. One should not fail to notice, however, that it is the presence of the back unrounded vowel in a system which causes this complexity. If such a vowel is lacking, /u/ is simply represented in terms of a governor |u| without |u| as a dependent feature. It is not obvious that "system-complexity" should be reflected in the representation of the sounds which tend to only occur in more complex systems. To be explicit: I will reject this correlation. In so far as fully specified feature structures in isolation represent complexity, this is phonetic (in particular, articulatory) complexity rather than typological complexity. The latter type of complexity can be derived from looking at the vowel system as a whole.

In the next section, I will introduce some further aspects of the present model. Firstly, it will be argued that the three features |i|, |u| and |a| are organized in a binary geometry, which leads us to postulate a node dominating |i| and |u|. This node, referred to as |y|, will turn out to share some properties with |ə| and [v] mentioned above. A second important point will be that the desire to discriminate between distinctive and non-distinctive information will lead us to adopt underspecification within our model. It will be shown that such forms of underspecification are not only economical but also lead to more optimal analyses.

Before we turn to the next two sections, which offer a discussion of some vowel harmony systems, there is one other line of argumentation in support of the present approach that I want to mention here.

In order to explain why certain segments fail to initiate or to interrupt a particular spreading process (even though, phonetically at least, they bear the relevant property), it is proposed in the current literature that such segments lack a specification on the relevant tier. Steriade (1987) argues that the absence of such specifications either results from the fact that the relevant feature is single-valued (universally or in the language at issue), in which case she speaks of *trivial underspecification*, or from the fact that one of the values of the binary feature has been left unspecified because it is not contrastive. In that case, Steriade speaks of *nontrivial underspecification.*

Here my concern is to suggest, without going into full detail, that certain cases mentioned by Steriade as examples of nontrivial underspecification turn out to involve trivial underspecification if we make use of the feature system adopted in this paper. If this is correct, it would show that our single-valued feature system is superior to the underspecification approach because it explains rather than stipulates why certain types of segments fail to trigger, or fail to interfere with, certain processes.

Steriade discusses certain dissimilation phenomena in Ngbaka and Ainu, involving the features [high] and [back], arguing that /a/ is crucially (but not trivially) unspecified for the feature [high] in Ngbaka and [back] in Ainu. Thus, the argument goes, we can explain that /a/ does not participate in certain processes that make reference to these features. Both cases will be analysed in section 3. Anticipating this more detailed discussion, I would like to point out now that the behaviour of /a/ follows straightforwardly in our model from the fact that it is exhaustively specified in terms of the feature |a|. The fact that this vowel does not interfere with processes which refer to height or backness, then, follows from trivial underspecification.

From these facts we may draw the conclusion that the cases Steriade uses to exemplify nontrivial underspecification theory in fact provide strong arguments in favour of a single-valued approach in that most – if not all – cases of so-called nontrivial underspecification turn out to be instances of trivial underspecification. In this regard, however, the choice of the feature system plays an essential role. In the examples just given /a/ "does not get in the way" if reference is made to "high" because the height dimension is represented by a single-valued feature "non-high" (i.e. | a|). In another example discussed by Steriade (from Tamil) the point is that /a/ has no specification for [back]. Here we derive the "irrelevance" of /a/, because the low vowel has no specification whatsoever indicating its position along the front-back axis.

2. HARMONY SYSTEMS

In this section I intend to illustrate the characteristics of the feature system proposed here by offering analyses of a number of harmony systems. Because I have chosen here to give a "broad" illustration, these analyses are rather schematic and incomplete, and are presented here in a largely "data free" manner. In almost all cases, however, I discuss fairly familiar data (for which references will be given) or I summarize results which are discussed in more detail elsewhere. The reader who consults this section looking for an introduction to the phenomenon of vowel harmony will end up frustrated. (S)he is referred to the various studies in Vago (1980), in particular the introduction and Anderson's contribution to that volume. A typological overview of vowel harmony is offered in Ultan (1973).

2.1. | i|*-systems*

Since dependent | i| represents ATR, it seems as if we cannot make a distinction at the phonological level between ATR-harmony and palatal harmony, as for example in Finnish and Hungarian. Indeed, I want to suggest that the two types of systems are closely linked, in that both involve the spreading of | i|. This is precisely what we want. Firstly, it has been claimed that there can be a smooth diachronic development from one into the other (cf. Svantesson 1985 on Mongolian), which suggests that the two are closely related, and, secondly, there seem to be restrictions on the possibility of combining palatal harmony and ATR-harmony in a single system, which suggests that the two do not involve independent features. The question as to whether the spreading | i| has dependent status

in both types of systems (as suggested in Van der Hulst 1987) will be discussed below.

2.1.1. ATR-systems

Typical ATR-systems have two sets of vowels, a [+ATR] set and a [–ATR] set. Williamson (1973, 1984) discusses a whole array of such systems, suggesting that a 2 x 5 system is prototypical. I will assume that such a "full" ten-vowel ATR-system is characterized as follows:

(12)	/i/	/u/	/e/	/o/	/ə/	|	/ɩ/	/ω/	/ɛ/	/ɔ/	/a/
	i	u	i	u	a	|	i	u	i	u	a
	|	|	|	|	|	|			|	|	
	i	i	a,i	a,i	i	|			a	a	

/ɛ/ is represented as | i→a | rather than | a→i | to ensure that only vowels in the [+ATR] set have a dependent | i|. In conjunction with this, the claim has to be that ATR-harmony involves spreading of dependent | i| only.

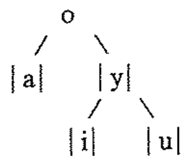
It is not clear from the representation that /ə/ characterizes the most marked combination, as is generally assumed. In fact, our framework has had very little to say about preferred and dispreferred feature structures, so far. We only know that the presence of a dependent | f| is most natural for segments which have | f| as a governor. This unmarked cooccurrence has been expressed in terms of the universal redundancy rule in (8).

From this point of view, /u/ and /o/ should be as marked as /ə/, although one would presumably want to obtain the ranking which reflects the usual pattern of decay in ATR-systems (cf. Williamson 1973, 1984, Lindau 1975, Van der Hulst, Mous & Smith 1986a,b):

(13) /i/ /e/ /o/ /ə/
/u/
Preferred --|--------|---------|----------|---> dispreferred

This could be obtained if we express formally that the features | i| and | u| have something in common, as opposed to | a|. This is not an unexpected manoeuvre. The idea that the properties denoted by | i| and | u| (when interpreted as dependents) can be grouped together as the "tonality" or "colour" features can be traced back to the work of Trubetzkoy (1939) and Jakobson (1941) (cf. also Donegan 1978). Furthermore, when interpreted as governors, these features are closely linked in that both involve tongue-body constriction. Let us assume, therefore, that | i| and | u| (disregarding their specific interpretations) form a structural unit which is opposed to |a|. For reasons independent of the present discussion, Ewen & Van der Hulst (1988) make a proposal of this kind, which they express as follows:

(14)



I will assume that (14) expresses the geometry of vocalic (or rather: place) features. There is the question as to what exactly the status of |y| is. This issue has not been fully explored at present and is discussed in more detail in Van der Hulst (forthc. b). Here, I will simply assume that |y| can occur without either |i| or |u|. As such it represents an incomplete specification which is usually provided with |u| or |i| to make it complete. Below, however, we will see that in certain cases we are forced to say that the incomplete |y| surfaces. I will interpret this as a parametric choice. Since |y| is not a "real" feature it has no interpretation independently of |i| or |u|. Occurring alone it represents the complete absence of any positive property. Occurring as a dependent it adds nothing to the interpretation of a feature structure; being "nothing" it can never govern |a| when incomplete.

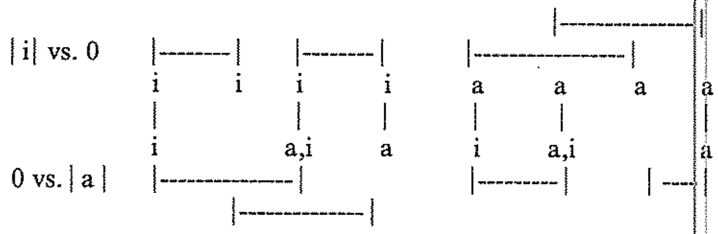
Given (14), we have a basis for saying that dependent |i| combines more readily with |u| than with |a|, because |i| and |u| are closer to each other to begin with. The generalization, then, would be that the closer a dependent to its governor, the more likely the combination. I.e., |i| is closest to itself – hence (8) expresses the most likely combination – and closer to |u| than to |a|. According to this /e/ is better than /o/, because its non-ATR counterpart already contains |i|. This reasoning gives us the scale of (dis)preferred combinations in (15).

This way of thinking about feature combinations, i.e. in terms of *government restrictions*, will be exploited further in this paper (cf. the discussion of Kpokolo below and of Finnish in section 2.1.2). But not all "segment structure conditions" can be interpreted as such. As just indicated, whether or not bare |y| is allowed to surface is a different type of restriction. We will also encounter "complexity restrictions", i.e. restrictions limiting the number of dependents that a feature structure can contain. Such complexity restrictions could possibly be reduced to government restrictions. A comprehensive theory of "segment structure conditions" is not offered at this stage, however.

As pointed out in Den Dikken (1987), the alternations which are usually identified with ATR-harmony can be analyzed in terms of |a|-spreading

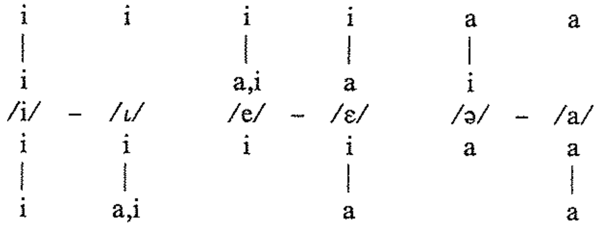
in a standard DP-feature framework. This is also true within the present framework. The array of possibilities we have for representing vowels along the dimension of height allows us to characterize two sets of four pairs. In one set the members of each pair differ in terms of |i|, whereas in the other set the difference involves |a|:

(15)



Given a tenvowel system, we therefore have, in principle, two ways of characterizing the ATR-alternations; I take the front/low vowels as examples:

(16)



Ambiguity arises if we allow /ɩ/ – /e/ and /ω/ – /o/ to "switch" representations. It is not at all unexpected that /ɩ/ and /e/ can both get the same two representations (in different systems of course). The phonetic interpretations of |i→i,a| and |i| are close, due to the fact that the two dependents neutralize each other's effect. The presence of |i| implies a narrowing of the constriction, whereas the presence of |a| has the opposite effect due to the lowering of the jaw. This is also in accordance with the fact that it is very difficult to keep apart /ɩ/ and /e/ (as well as /ω/ and /o/) in ATR-systems.

I would like to suggest that a ten-vowel system with root-controlled harmony is indeed phonologically ambiguous to some degree. However, I will also assume that due to certain characteristics, specific systems can always be "identified" as either |i|-spreading or |a|-spreading. For example, in so-called dominant harmony systems a decision can be made depending on which feature appears to be dominant. Hence in Kalenjin (Hall et al. 1974) or Tunen (Van der Hulst, Mous & Smith 1986a) dominant morphemes are [+ATR], indicating that |i| is the spreader. However, in Chukchee or Nez Perce (cf. section 2.3), dominant morphemes have low vowels, implying that |a| is spreading. However, in root-controlled systems evidence might also be available pointing one way or the other, for example if contexts can be found in which for some reason or other the default value has to appear.

Another interesting result arising from the above ambiguity is that languages may start to show signs of both harmonies independently. A number of such cases are discussed in Van der Hulst, Mous & Smith (1986b) and in Van der Hulst & Smith (1987); an example is also given in section 4.2.1. The typical situation seems to be that affix vowels show a three-way alternation, e.g. between /ɩ/, /i/ and /e/, where the second alternant results from |i|-spreading and the third from |a|-spreading. I will not go into these cases here. Rather, I would like to discuss another ATR-system, which is more complex than the tenvowel system discussed above, i.e. that of Kpokolo (discussed in Kaye, Lowenstamm & Vergnaud 1985). This system comes out as follows in the present feature system:

(17)	/i/	/e/	/ɨ/	/ə/	/u/	/o/	|	/ɩ/	/ɛ/	/Ɨ/	/a/	/ɜ/	/ω/	/ɔ/
	i	i	u	u	u	u	|	i	i	u	a	u	u	u
	|	|	|	|	|	|	|		|			|	|	|
	i	a,i	i	a,i	u,i	a,u,i	|		a			a	u	a,u

Observe that the central vowels /ɨ/, /ə/, /Ɨ/ and /ɜ/ are represented with a governing |u|, whereas back rounded vowels have |u → u| (cf. 11a).

The advanced counterpart of /a/ in Kpokolo is /ə/, which is also the regular counterpart of /ɜ/. Apparently, then, the result of harmonizing /a/ has to be merged with the harmonic congener of /ɜ/. To deal with this, I will assume that, in Kpokolo, |a| cannot govern |i|. (In fact, it does not govern |u| either, so that we will say that it cannot govern |y|; this can be interpreted as a parametric choice. Cf. Van der Hulst forthc. b.) When |i| spreads to /a/ an illformed representation will therefore arise. I assume (and again this has to be a parametric choice) that in such cases spreading is blocked unless a repair principle has been set in the grammar. In Kpokolo the repair principle has been set such that |a| is "demoted" to a dependent role, resulting in the "appearance" of |y|. The surface representation is derived by adding the governor |u|, which apparently acts as a default governor. Presumably, another possibility would have been to insert |i|; both possibilities lead to a neutralization of the harmonic congener of /a/ with another underlying segment:

(18)	a		y		u
	|	→	|	→	|
	i		a,i		a,i

An additional fact about Kpokolo is that rounded vowels alternate with central vowels. Given our featural representation, this involves the presence or absence of dependent |u|.

At this point I close the discussion of ATR systems. Systems which have been analysed as involving [–ATR] will be discussed in section 2.3 and in section 4.1.2.

2.1.2. Palatal systems

Prime examples of palatal systems are the Finugric languages, of which Finnish and Hungarian have been rather well studied. In this section, Finnish will be discussed (Campbell 1980, Anderson 1980, Skousen 1970). Hungarian, which has a limited labial harmony system alongside palatal harmony, is discussed in the next section. Given the phonetic interpretation of our features, it would seem that (19) gives the most straightforward representation of the Finnish vowel system:

(19)	/i/	/e/	/y/	/u/	/ö/	/o/	/æ/	/a/
	i	i	i	u	i	u	a	a
		|	|		|	|	|	
		a	u		a,u	a	i	

If harmony involves the spreading of dependent |i|, however, the representation of the front rounded vowels has to be different:

(20)	/i/	/e/	/y/	/u/	/ö/	/o/	/æ/	/a/
	i	i	u	u	u	u	a	a
		|	|		|	|	|	
		a	i		a,i	a	i	

In Van der Hulst (1987, forthc. a), I adopt the representation in (20), which implies that there is no difference, in terms of the phonological analysis, between ATR-harmony and palatal harmony: both involve dependent |i|-spreading. It is probably the case, however, that palatal harmony is different phonetically in that the harmonic congeners differ more in their constriction location than in the position of the tongue root. Therefore, I would now like to propose that what differentiates the two systems is the inability of |u| to govern |i| in systems of the Finnish type. This implies that we have to accept that in such systems |i| spreads, both as a governor and as a dependent. Whether a spreading |i| comes out as governor or dependent on the target is determined by the governing restriction, i.e. spreading |i| to |u| will always result in |i → u|. In this respect, note that palatal harmony is also different from ATR-harmony in that |a| can govern |i|. Hence spreading |i| to /a/ results in |a → i|.

In section 3.3 I will give additional support for analyzing |u| as a systematic dependent in palatal harmony systems.

/i/ and /e/ do not have harmonic counterparts in the system; they are neutral. For this reason it is questionable whether these vowels should contain |i| in their representations, rather than being specified as |y| and |y→a|, respectively. This would in any event be the appropriate representation for those instances of /i/ and /e/ that fail to initiate |i|-spreading themselves, in which case they act "transparently". |y| could be completed with |i|, the only governor which does not appear underlyingly, by a "complement" rule. The issue of transparency is discussed separately in Ewen & Van der Hulst (1986), the addition section 5. As suggested in Ewen & Van der Hulst (1986), the addition of governors reflects a "complement principle" reminiscent of the complement rules of Radical Underspecification Theory. It may either be the case that the governor is not used underlyingly at all or that it is not used governing a particular other feature. The latter situation holds in Finnish, the former in the case of Chamorro (discussed below). If this is correct, then it will not be necessary to formulate explicitly a fill-in rule in such cases. In Kpokolo, where we also needed the addition of |u|, the situation is different, because in that case |u|-addition has the status of a language-specific repair strategy, which could also have inserted |i|.

We also encounter palatal systems which have harmonic alternations of the following type:

(21) /i/ – /u/ /e/ – /o/ /æ/ – /a/

We find this for example in Chamorro (Poser 1982). At first sight we would like to assign the following representation to a six vowel system of this type:

(22)
$$\begin{array}{cccccc} i & u & i & u & a & a \\ & & | & | & | & \\ & & a & a & i & \end{array}$$

But, given (22), we cannot account for the harmonic pairs without a feature-changing operation. I therefore suggest (23) as the appropriate representation:

(23)
$$\begin{array}{cccccc} i & y & i & y & a & a \\ & & | & | & | & \\ & & a & a & i & \end{array}$$

Here |y| is completed by |u|, which is the governor not used underlyingly.

2.2. |i| *and* |u|*-systems*

Various systems, especially in the Altaic family, have both palatal harmony and labial harmony. In Turkish, labial harmony is limited to high vowel targets. Due to the fact that, at least for high vowels, two harmonies operate together there is a four-way alternation: /i, y, ɨ, u/ (Clements & Sezer 1982). We must represent the vowel system as follows:

(24)
$$\begin{array}{cccccccc} /i/ & /y/ & /ɨ/ & /u/ & /e/ & /ö/ & /a/ & /o/ \\ i & i & y & u & a & a & a & a \\ & | & & & | & | & & | \\ & u & & & i & i,u & & u \end{array}$$

Thus, as in the case of Finnish, |u| is not a possible governor. /ɨ/ is not specified with either |i| or |u|, giving |y|, which is also the underlying representation of a high suffix vowel. Observe that |y| has to surface as such. Adding |i| or |u| would neutralize the contrast with the front unrounded and back rounded vowels. There is no "complement" feature, then, and no "repair rule". Turkish allows "the incomplete vowel".

The fact that low vowels do not undergo |u|-spreading has to be accounted for in terms of a "negative condition" of some kind. We cannot, as in the binary framework, assign [–round] to these vowels, nor is there a basis for invoking a government restriction, since the two low unrounded vowels do have rounded counterparts in the vowel system. In sections 4.1.1 and 5 I will come back to the form and role of such conditions. Ultimately, of course, we would like to find a less stipulative account for the limitations on rounding harmony in Turkish, e.g. in terms of government restrictions, especially since this kind of restriction is recurrent (cf. section 3.2.3). Given that |u| is subjoined to |y|, which characterizes high vowels, it is to be expected that |u| associates less easily with low vowels. So, we could say that although |a| governs |u| in the underlying representations it does come to govern |u| by a spreading process.

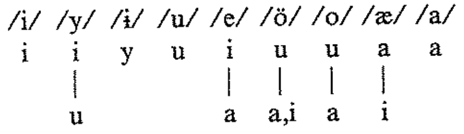
Another type of reduced rounding harmony occurs in Uygur and Hungarian (cf. Sezer & Wetzels 1986). In Uygur the following two vocalic alternations involving the high vowels exist:

(25)

a.	sfx	y	u	b.	sfx	i	y	u
	stem	i,y,e,ö,æ	u,o,a		stem	i,e	y,ö	u,o,a

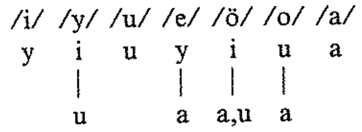
The surface vowel system of Uygur is the same as that of Finnish (cf. 19). The three-way alternating suffix can be handled by including in the underlying inventory a vowel specified as |y|. Uygur does not allow this bare |y| to surface and assigns |u| to it if neither |i| nor |u| spreads onto it; this is the case if an /a/ precedes. |u|-addition is a language-specific statement, as in Kpokolo. The high two-way alternating vowel has the |u| underlyingly. The underlying system of Uygur, then, is:

(26)



Let us now turn to Hungarian. The vowel system is analyzed as follows (Van der Hulst 1985, Ringen 1988a):

(27)



Hungarian has palatal harmony and limited rounding harmony. The palatal harmony is straightforward and affects all vowels. It involves spreading of |i|. /i/ is neutral and transparent; its representation is simply |y|, because the presence of |i| is predictable. /e/ also shows transparent behaviour, but it is not neutral: /e/ is the harmonic counterpart of /a/. Long and short /e/ differ phonetically – short /e/ is lower than long /e/ – and, in conjunction with that, long /e/ is practically always transparent, whereas short /e/ typically is not. I will account for this as follows. I will assume that |a| can never govern |i| in long vowels. Spreading |i| to long |a| will therefore result in |i→a|. Most short /e/s have the G-relation reversed: |a→i|. These vowels, then, trigger palatal harmony. Only those instances of short /e/ which are transparent get the representation in (27), which is also valid for all long underlying /e/s. As in Finnish, |y| will be completed by |i|. Hence, we build some abstractness into our analysis in that |y/i→a| and |a→i| are mapped onto the same segment if associated with a single vowel slot.

The amount of abstractness could actually be reduced if we assumed that the transparent /e/ is represented as |a,y|, i.e. with the G-relation unspecified. We have not suggested this possibility earlier, but it is in fact the case that the G-relation is non-distinctive, and thus redundant, if there is just one series of mid vowels. I suggest, tentatively, that we make use of the possibility that the G-relation can (or must?) be left unspecified.

Rounding harmony only involves mid (short) vowels. I will now discuss three alternation types which are particularly fascinating because each involves the low vowel /a/. The following vocalic alternations are involved:

(28) a.

sfx	e	a
stem	i,e,y,ö	u,o,a i,e (t.)

b.

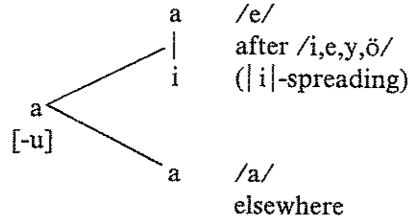
sfx	e	ö	o
stem	i,e	y,ö	u;o,a i,e (t.)

c.

sfx	e	ö	a	o
	i,e	y,ö	a i,e (t.)	u,o

("t." means "transparent"; transparent vowels do not trigger |i|-spread; cf. above.) The interesting challenge is to represent the difference between the above 2, 3 and 4-way alternating suffixes. A two-way (short) alternating suffix vowel is derived in (29):

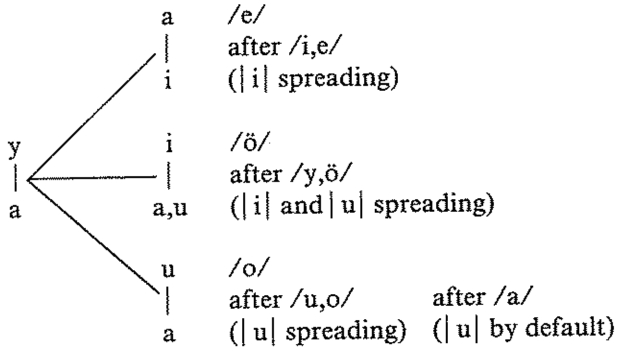
(29)



Since two-way alternators do not undergo rounding harmony, they have to be provided with a negative condition. (All high vowels have this condition too.)

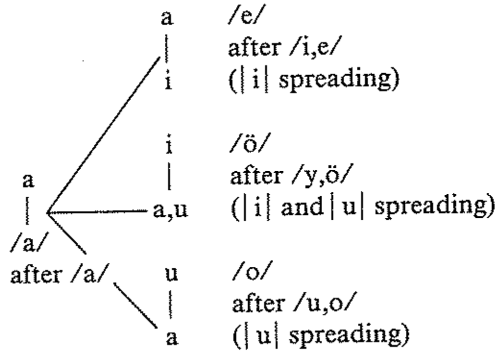
To derive three-way alternators, I allow an incomplete feature structure which cannot surface as such and which is minimally distinct from the representation of /a/. This has to be |y→a|. A repair rule filling in |u| will prevent |y→a| from surfacing (i.e. after /a/, from which |i| nor |u| spreads). The careful reader will object that |y→a| is already in "use" as the underlying representation of transparent /e/. Interestingly, however, all three-way alternators are short and, in addition, transparent short /e/s, rare as they are, never occur in suffixes. Suffixal /e/ is always involved in one of the alternation types discussed here. We will have to say, then, that the repair rule filling in |u| only applies to suffix vowels, bleeding the rule which fills in |i| in the transparent short /e/s occurring in stems. The three-way alternation, then, is derived as in (30):

(30)



Hungarian also has suffixes showing the four-way alternation e/ö/a/o. In this analysis the relevant vowel is represented as |a| without the negative condition. Hence the four-way alternation is derived as follows:

(31)



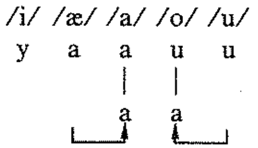
In (30) and (31) I have assumed that the spreading of |i| and |u|, as well as default |u| assignment, are "structure preserving" in the sense that the resulting feature structures are the same as the underlying segments in terms of what governs what.

Of course many aspects of the Hungarian vowel harmony system have been left unconsidered here. Yet, I believe that the above captures the basics of the system. A much more extensive analysis of the suffixes in Hungarian, using an i/u/a-system without dependency, is offered in Kornai (1987).

2.3. |a|-*systems*

In Van der Hulst & Den Dikken (1987), it is shown that the harmony systems of Nez Perce, Chukchee and Middle Korean can be understood in terms of |a|-spreading. Consider Nez Perce (Zwicky 1971, Hall & Hall 1980). The harmonic relations have been indicated by arrows. The lowering is conditioned by the low vowels /a/ and /o/:

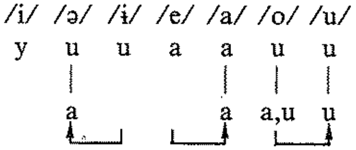
(32)



The vowel /æ/ is represented as |a|. A similar analysis, with a completely empty specification for /æ/, is proposed in Anderson & Durand (1988). I do not reject the option of leaving one of the vowels incomplete, but I see no purpose for it here. The representation of /i/, which has no harmonic counterpart, deserves some attention. Some morphemes with /i/ trigger lowering. These should be specified as |y→a|. Interestingly, the other /i/s are transparent to |a|-spreading, which suggests that they are compatible with the spreading value. I will come back to the representation of /i/ in section 5.

Middle Korean is highly similar, but has central vowels (Hayata 1975, Kim-Renaud 1986):

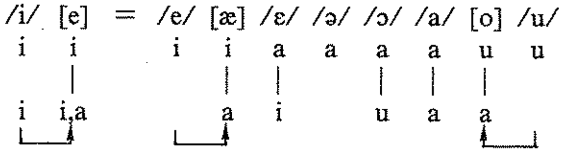
(33)



As in Nez Perce, the vowels specified with |a| are both the triggers and the "output" of harmonic spreading of |a|. Again /i/ has no counterpart, and it appears to be opaque this time (cf. section 5).

Let us now consider Chukchee, which has the most complicated system (Krause 1980, Kenstowicz 1983):

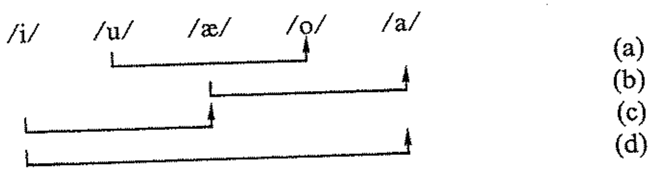
(34)



Three remarks are in order. First, note that harmony is not structure preserving, in the sense that the derived vowels, between square brackets, are different from all underlying vowels of Chukchee. Secondly, some "schwas" appear to be non-triggers and transparent. We could represent them as plain |y|, which becomes |a→y| by a language-specific default rule. This representation is equivalent to plain |a| on the assumption that a dependent incomplete |y| literally means nothing.

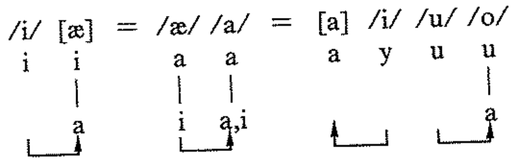
In Coeur d'Alene we also find |a|-harmony. The following is based on the analysis presented in Cole (1987), who uses standard SPE features. An interesting aspect of this harmony, ignored here, is that a leftward |a|-spread is triggered by faucal consonants. It brings about the following shifts:

(35a)



If all alternations are seen in terms of |a|-spreading, we have a problem in cases (c) and (d). To solve this I will postulate a double underlying source for /i/ (as Cole does): |i| and |y|; the latter is later completed as |i|. In addition we have two representations for both /a/ and /æ/, one underlying and one derived:

(35b)



Progressive harmony is triggered by /a/ and /o/, the only two vowels having |a| underlyingly. Cole reports that some /æ/s trigger this progressive harmony, too. In terms of our analysis these /æ/s would have the first representation in (35b), the one which is normally the output of lowering /i/.

All four systems have been mentioned in other analyses as examples of [–ATR] spreading. Clearly, such an analysis is inconceivable in this framework. It has been shown, however, that these cases are straightforward examples of a harmony type which is predicted to exist within the present approach.

2.4. |i|, |u|, |a|-systems

Van der Hulst & Smith (1985) analyse three harmony systems, those of Djingili, Nyangumarda and Warlpiri (cf. also Rennison 1987b, who discusses these systems too). A common feature of these systems is that

the vowel system is simple, consisting of three vowels only: /i/, /u/ and /a/. It is not my intention to give detailed analyses here. In Djingili we find an alternation between /i/ and /a/, i.e. /a/ goes to /i/ if /i/ follows. In Nyangumarda suffixes show a three-way alternation, so here /i/, /u/ and /a/ spread rightwards. Finally in Warlpiri we find an alternation between /i/ and /u/. A three-vowel system will be represented underlyingly as follows:

(36)	/i/	/u/	/a/
	i	u	a

This forces us to analyze these systems systematically in terms of governor-spreading. Alternating vowels will be represented as completely unspecified (bare "V") or as specified only with | y |; I leave this issue open here. Any vowel which is invariant (i.e. specified) will block the spreading, i.e. /i/s block /u/ and /a/ spreading, /u/s block /i/ and /a/ spreading and /a/s block /i/ and /u/ spreading (cf. section 5).

2.5. *Conclusions*

In this section a wide variety of harmony systems has been discussed. The purpose here was to show that common alternations arising from vowel harmony can be analyzed rather straightforwardly within the present feature system. Important issues for further research include the status of | y | (and ways of completing it) and the role of government restrictions. Due to the programmatic nature of our exposition, a number of problems have been ignored or noted without being solved. Some of these are addressed in Van der Hulst (forthc. b).

In the next section, I will consider further systems which are different in terms of the conditions under which harmony takes place.

3. PARASITIC HARMONY

In this section, I will discuss a number of cases which involve harmony with respect to some feature | f | which only takes place on the condition that the vowels involved already agree with respect to some other feature. This agreement is either a lexical property or the result of another harmonic spreading process. Cases of this type have been analyzed by Cole & Trigo (1988) in terms of a "colinking" principle and by Mester (1986, 1988), making use of "dependent tier ordering". The joint feature of these accounts is that a particular harmonic process is "parasitic" in some way or other (the term parasitic was first suggested in Steriade 1981). In this section I want to explore how parasitic harmonies have to be dealt with within the present model. It will become clear that Mester's use of dependency is only partly similar to the concept of dependency that is used here. In all cases, except for (37c), his use of the notion dependency would involve subjunction in our terms. Our discussion will be limited to a number of cases which Mester (1986, 1988) discusses and of which the relevant property can be stated as follows (these cases, including Mester's analyses, are discussed more extensively in Den Dikken & Van der Hulst 1988, section 1.2.2.4):

(37) a. *Ainu*
like rounding implies like height
b. *Ngbaka, Yawelmani, Turkic, Khalkha*
like height implies like backness or rounding
c. *Turkic* (e.g. *Kirghiz*)
like backness implies like rounding

Mester deals with the facts under (37a) and (37b) by assuming that the binary features [back], [high] and [round] can enter into dependency relations:

(38)	a. [high]	b. [back]	c. [round]	(=dependent)
	|	|	|	
	[back]	[high]	[back]	(=governor)
	Ainu	*Ngbaka* etc.	*Kirghiz*	

In this section, I will explore how parasitic harmonies like those analyzed by Mester have to be dealt with in our framework.

3.1. Like rounding implies like height: Ainu

Itô (1984) discusses a dissimilatory suffix in Ainu. The vowel of this suffix either is identical to the vowel of the preceding stem or it is high. In the latter case it will be /i/ if the stem vowel is /u/ or /o/, /u/ if the stem vowel is /i/ or /e/ and either /i/ or /u/ if the stem vowel is /a/. From this polarity effect, Mester (1986, 1988) concludes that vowels of like backness/roundness are necessarily of the same height (and hence identical). So the high suffix vowel cannot be either /i/ after /e/ or /u/ after /o/.

Strictly speaking, we cannot conclude that a restriction on /e-i/ or /o-u/ sequences holds on the basis of the polarity behaviour of one affix. Furthermore, the assumption here is that the sequences /i-e/ and /u-o/ are also disallowed, a restriction which does not seem to follow from the data which Itô considers, because the discussion is limited to this one suffix. Be this as it may, we do have to give an account of the polarity behaviour of the suffix in question.

Mester's account involves the OCP and dependent tier ordering. The feature [high] is dependent on the feature [back]. Mester assumes that the OCP demands the fusion of identical adjacent features even if one has a dependent feature which the other lacks. Therefore, if [high] is dependent on [back], two segments of like backness cannot be different with respect to their value for height. I formulate the relevant assumption as follows:

(39) The OCP ignores differences in dependent information

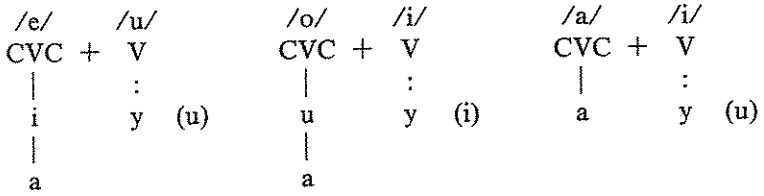
An obvious question, of course, is how we will deal with a language which does not disallow a combination of e.g. /i/ and /e/. Mester's answer is that in those cases [high] is not dependent on [back]. The two features are independent.

Let us now look at Ainu in terms of our model. The vowel system is analyzed as follows:

(40)	/i/	/u/	/e/	/o/	/a/
	i	u	i	u	a
			|	|	
			a	a	

Both /i/ and /e/ are | i |-specified; /u/ and /o/ are not | i |-specified but | u |-specified instead. To deal with the polarity effect in the Ainu suffix under consideration, stems can be provided with a floating | y |, the mere presence of which implies that it is different from the stem vowel, simply assuming a standard interpretation of the OCP. The suffix vowel itself is completely empty, e.g. bare "V". What the OCP does for us here is render a language-specific statement of the rule, completing | y |, superfluous. In (41) I indicate between parentheses which feature is filled in to complete | y |. For stems with an /a/, the second vowel has to be specified underlyingly as either /i/ or /u/. In the absence of | y | the stem vowel spreads to the suffix slot.

(41)	/i/		/u/		/u/		/i/		/a/		/i/	
	CVC	+	V		CVC	+	V		CVC	+	V	
	|		:		|		:		|		:	
	i		y	(u)	u		y	(i)	a		y	(i)



As a general strategy for handling polarity effects, the representation of an unspecified node which dominates the features for which polarity holds might be fruitful and worth exploring further. In our approach, the issue of "ignoring" dependents does not appear to be relevant, however. Nothing in this particular case would change if | i | and | u | simply "combined" with | a |, without having a G-relation. Not irrelevant, of course, is the specific choice of our feature system and the geometry of its organization.

There are many languages which simply allow a sequence like /e/ + /i/. As mentioned above, Mester would say that in such cases the features [high] and [back] do not enter into a dependency relation. We cannot do so. At best, we could say that the G-relation has been left unspecified, committing ourselves to the prediction that if the G-relation is not redundant, a sequence of a high and a mid vowel is excluded. Such a prediction is wrong, however, as there are many languages having two series of mid vowels without cooccurrence restrictions of the relevant kind. This means that, for us, not only is (39) inapplicable in the case of Ainu, but also that it is actually wrong for many other cases where difference in dependents is *not* ignored.

3.2. Like height implies like rounding

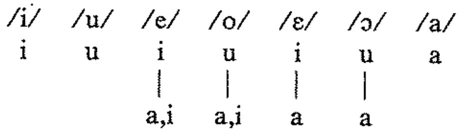
3.2.1. Ngbaka

In Ngbaka a word cannot contain two different mid vowels or two different high vowels, according to Wescott (1983) (cited in Mester 1986:33). In addition there is ATR-harmony:

(42)
a. /i/ → not /u/
b. /u/ → not /i/
c. /e/ → not /ɔ/, /ɛ/, /o/
d. /o/ → not /e/, /ɛ/, /ɔ/
e. /ɔ/ → not /ɛ/, /e/, /o/
f. /ɛ/ → not /e/, /o/, /ɔ/

In Mester's treatment [back] is dependent on [high]. Hence if two vowels have the same height, principle (39) forces them to be collapsed so that they will also share the value for backness. In our feature system, the vowel system has to be represented as follows:

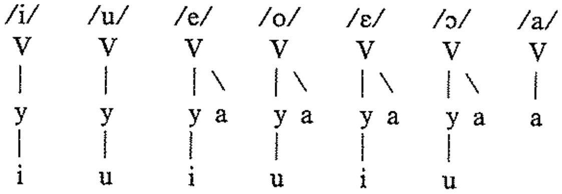
(43)



We cannot attribute the cooccurrence restrictions in Ngbaka to (39). If we said that (39) is valid, we would also disallow combinations of high and mid vowels of like backness, since high and mid vowels of like backness differ only in that the latter have a dependent | a |.

Even if we ignore this point, there is a further problem, however. If (39) is to rule out sequences like /i/ + /u/, | y | has to count as identical for both segments. The wrinkle is, of course, that in these two segments | y | dominates | i | and | u |, respectively, which are not dependents of | y |, but rather daughters and, more specifically, governors. I.e. in full, (43) looks as in (43′):

(43′)



(Representations as in (43′) are motivated and discussed in detail in Van der Hulst, forthc. b.) This does not mean that the cooccurrence restrictions in Ngbaka are random within our representation of the vowel system, nor that the OCP is irrelevant. I suggest that the relevant generalization can be straightforwardly captured by saying that in Ngbaka vowels have to agree with respect to | y | if they are identical in all other respects. (The situation is, in fact, the reverse of what we have seen in Ainu, where there has to be disagreement with respect to | y |.) The intuition that this has something to do with the OCP derives from the fact that the required agreement with respect to backness is conditioned by having all other information identical. If we want to derive this as an OCP-effect, we will have to reformulate (39) as follows:

(39′) The OCP ignores differences in subjoined information

I use the term 'subjoined information' here to refer to the "second-degree" vocalic elements | i | and | u |, as opposed to the "first-degree" elements

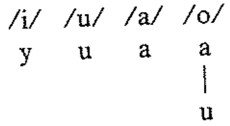
| y | and | a |. Therefore, differences regarding the content of | y | will be ignored even if the OCP applies to | a |, rather than | y | itself.

(39′), although making the correct prediction for Ngbaka, cannot be considered to be a universal principle. Many languages do allow sequences like /i/ + /u/. We must assume, therefore, that (39′) is parametrized in the sense that languages choose the hierarchical level at which it is relevant. This would also appear to be the conclusion to be drawn from Yip (1988).

3.2.2. Yawelmani

Mester also proposes to analyze Yawelmani rounding harmony in terms of the OCP. In our system the analysis of Yawelmani would run as follows:

(44)



Rounding harmony takes place among vowels of like height. Hence, Yawelmani has parasitic | u |-harmony, which derives from obligatory agreement among vowels being identical in all other respects, i.e. (39′) is applicable in its most general form. Note that /i/ has to be incompletely specified, because otherwise an additional stipulation has to be made that in the case of high vowels | i | has to be wiped out. As in previous cases (e.g. Finnish), | y | is completed with | i | by a "complement" rule. (This part of the analysis derives from Ewen & Van der Hulst 1985.)

3.2.3. Turkic languages

If rounding harmony applies to the whole vowel system, there is simply an unconditioned rule of | u |-spreading. If the vowel system is as in Turkish, this would imply four logical combinations of trigger and target. In Steriade (1981) it was shown that rounding harmony in many Turkic and some other languages is "parasitic" on identity with respect to height specifications. Steriade discusses cases in which harmony either holds only between vowels of like height (as in Yawelmani; cf. (45b)) or only between vowels of a particular (like) height (cf. (45c,d)). However, we also get cases which are "mixed" in that we see harmony between all vowels of like height and between particular vowels of unlike height (cf. (45e)) or between particular vowels of like height and particular vowels of unlike height (cf. (45f,g)); in the following table a "+" indicates that rounding harmony takes place between two low vowels (AA), two high vowels (II), a low and a high vowel (AI) and a high and a low vowel (IA). (under i-ii I list the possibilities we have for | u |-spreading):

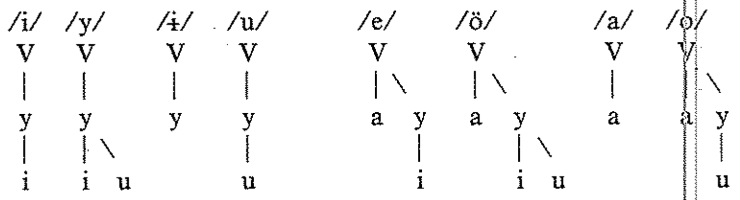
(45) i. Non-parasitic | u |-spreading; partial if | a | is excluded as target so that we only get the case AI (i.e. stem vowel "low" suffix vowel "high").

ii. Parasitic harmony; partial if (39′) is limited to | y | or | a | so that we only get the case II or AA, respectively.

iii.	AA	II	AI	IA	
a.	+	+	+	+	(full non-parasitic harmony)
b.	+	+			(full parasitic harmony)
c.	+				(partial parasitic harmony: only for | a |)
d.		+			(partial parasitic harmony: only for | y |)
e.	+	+	+		(full parasitic and partial non-parasitic harmony)
f.		+	+		(partial non-parasitic harmony)
g.	+		+		(partial parasitic and non-parasitic harmony)

On the basis of Korn's descriptions, it would seem that almost all systems in (45) are attested in the Turkic languages. Kirghiz is an example of (45e). Turkish falls under (45f). To make clear precisely how principle (39′) would have to operate in cases of this type, I will represent the system of Kirghiz in full ((46), then, is equivalent to (24)):

(46)



If (39′) is set with respect to | y | and/or | a |, we expect that vowels of equal height not only agree in rounding but also in palatality. This is not contradicted by the facts; the Turkic languages also have palatal harmony. Since palatal harmony usually applies to the whole vowel system, it does not derive from (39′), however. Note that setting (39′) with respect to | y | does not imply that vowels having | y | as a governing node have to agree with vowels having | y | as a dependent node.

3.3. Like backness implies like rounding: Kirghiz

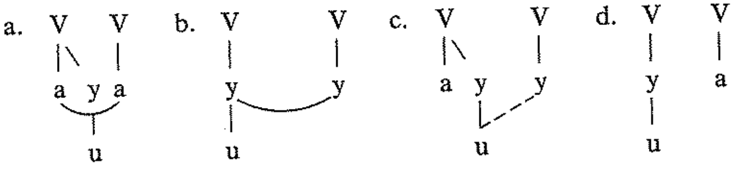
As discussed above, in Kirghiz | u |-harmony holds among vowels of identical height, and among vowels of different height only if the stem vowel is low and the suffix vowel high. As reported in Johnson (1980) | u |-harmony only holds in the sequence IA if both vowels are front, i.e. if palatal harmony has also applied. Korn (1969) reports many more cases in which | u |-harmony applies over spans of front vowels only. The goal of this section is to account for the fact that rounding harmony can be parasitic on spans of front vowels. Mester accounts for cases of this type by assuming that the feature [round] is dependent on the feature [back] (as in (38c)). Hence vowels sharing a specification for backness (not only underlyingly, but also if due to a harmony rule) must agree in roundness, so that there is no need for an independent rule of rounding harmony. That parasitic rounding harmony only takes place in front words follows from the fact that [−back] is the spreading value. Back vowels are characterized by the absence of a specification for [back]. Hence no parasitic harmony will take place in back words, although, given the assumptions of underspecification theory, such a state of affairs could hold in a language in which [+back] is the lexically marked value.

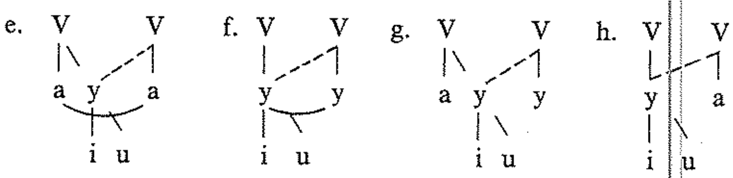
In our terms, this parasitic harmony would come close to the "spirit" of (39) in its original form. | u | is dependent on | i | and it "spreads" because vowels come to share | i |, not through the OCP, but by means of a rule spreading | i |. Rather than invoking (39), next to (39′), I will assume that parasitic | u |-harmony is an "A-over-A" effect. As before, | y | plays a crucial role in our analysis. Recall that in systems having palatal harmony, | u | cannot govern | i |. Hence if | u | and | i | occur together, | u | is dependent on | i |. But this can only be the case for the low vowel /ö/ if we assume | y |, otherwise | u | and | i | would both be dependent on | a |, without | u | and | i | having any special relation. That this condition is fulfilled can be seen by consulting (46) above. I will now say that in Kirghiz palatal harmony does not apply to | i | but rather to "| i |-bar", i.e. | y | iff headed by | i |.

In Kirghiz, then, spreading of | u | seems rather complex in that three different processes are involved:

(47) a. Fully parasitic | u |-harmony:
(39′) "on" for | a | and | y | causes fusion in (48a,b,e,f)
b. Non-parasitic | u |-spreading:
due to neg. condition on | a | only in case (48c)
c. | i |-bar spreading: cases (48e-h)

(48)





Kirghiz is of course very close to having an independent rule of non-parasitic unlimited | u |-spreading, and one might wonder why a system having a full non-parasitic | u |-spreading rule would ever change to a system as that of Kirghiz.

3.4. Conclusions

In this section we have surveyed a number of cases which differ from the harmony systems discussed in section 2 in terms of the way in which harmony in conditioned. Clearly, even though the cases considered have been analysed consistently, it is unlikely that I have succeeded in developing a comprehensive theory of parasitic harmony. There are other cases to be considered (e.g. Vata, as discussed in Kaye 1982; Bari, as discussed in Hall & Yokwe 1978). Yet I hope that I have made clear that the present model offers interesting ways of approaching the issue.

In the next section, I will review a number of cases which pose an interesting challenge to the present system.

4. APPARENT PROBLEMS

In this section I will discuss a number of cases which could be considered problematical for the single-valued feature system proposed here. Such cases are of two types. In one type of case we are faced with the apparent necessity of referring to the "wrong" value of a particular feature, either because both values are necessary or because the "right" value is seemingly playing the role of the default value. In the other type of case the problem appears to be that we seem to need an expression in a rule which cannot be formulated due to the choice of features.

Here I will discuss a number of instances of both cases. A few of them have already been discussed for other reasons, so that I will simply refer back to the relevant sections, where an analysis is proposed within the bounds of the present single-valued system. In the other cases I will briefly indicate here that, contrary to our first impression and/or claims in the literature, an analysis is possible. For some problematical cases I have no satisfactory solution at present.

4.1. Reference to the "wrong" value

4.1.1. The wrong value as a blocker

In our analysis of Hungarian rounding harmony it became apparent that we have to block vowels from undergoing the spreading process without being able to attribute this to a government restriction or general target condition. In particular we saw that occurrences of the vowel /a/ represented as | a | should not undergo | u |-spreading. A better-known case in which we run into the same problem involves ATR-harmony in Kalenjin, as discussed in Hall et al. (1974). The problem raised by this case is discussed in Dresher (1985) and in Ringen (1988b). The crucial point is that we have to prevent certain low vowels from undergoing ATR-harmony while in general low vowels have an ATR-congener. In binary systems we can handle cases of this type by assigning a negative feature specification to the vowels at issue:

(49) a. Hungarian: [–round] b. Kalenjin: [–ATR]
| |
V V

Observe, however, that such cases would also be problematical for a proponent of radical underspecification theory, who is forced to use both values lexically in the same environment. Having both values lexically leaves unaccounted for the fact that the negative specifications play a "passive" role only (cf. Dresher 1985).

In a single-valued approach, we are forced to a more principled treatment. We have to invoke a negative condition, which is formally distinct from a phonological feature. I therefore suggest that we allow such *negative conditions*. The concept of negative conditions has also been proposed within the framework of Unification Grammar. It has been suggested in Karttunen (1986) and Kasper & Rounds (1986) that we might make a difference between specifying a feature with a value and imposing a condition saying that a particular feature does not have (and may not get) a particular value. "A negative constraint attached to some structure A limits the class of structures that can be unified with A. It is not part of the content of A itself" (Karttunen 1986:27). I suspect that a translation of autosegmental spreading into the unification formalism will reveal that negative conditions give us just the power we need here, but I leave this for future research.

4.1.2. [–ATR]-spreading

In section 2.3, a number of | a |-harmony cases were discussed, which, as we noted there, have been advanced as examples of [–ATR]-spreading. Recently another case of alleged [–ATR] harmony has been revealed. Archangeli & Pulleyblank (in press) suggest that vowel harmony in Yoruba involves leftward spreading of [–ATR], and as such their analysis raises a problem for the single-feature framework assumed in much recent work including my own. I will now show, however, that harmony in Yoruba involves | a |, rather than [–ATR]. The dialect of Yoruba under consideration is claimed to have a seven-vowel system:

(50) /i/ /u/
/e/ /o/
/ɛ/ /ɔ/
/a/

The high mid and low mid vowels do not cooccur, but in addition /e/ and /o/ do not occur to the left of /a/. Furthermore, /ɛ/ and /ɔ/ can only precede the high vowels /i/ and /u/ if the latter are word final, i.e. the sequence in (51) is illformed:

(51) *ɛ/ɔ – i/u – V

Archangeli & Pulleyblank claim that the data can only be straightforwardly accounted for if [–ATR] spreads from right to left, [+ATR] being the default value. /i/ and /u/ are opaque, as they lack a [–ATR] counterpart and thus the gap in (51) is explained: [–ATR], coming from the right, cannot reach the vowel in the first syllable, which will have to end up as [+ATR] by default.

In order to analyze the data in terms of | a |-spread, I must assume that the vowel system can be represented in the following way:

(52)

/i/	/u/	/e/	/o/	/ɛ/	/ɔ/	/a/
i	u	i	u	i	u	a
|	|			|	|	
i	i			a	a	

The most remarkable aspect of this representation is presumably the fact that high mid vowels /e/ and /o/ are represented as [–ATR] high vowels. i.e. /e/ is analyzed as | i | and not as | i → i,a |. It will be clear that a featural analysis as in (52), anticipated in section 2.1.1, permits a different view of the spreading process. Segments which in Archangeli & Pulleyblank's analysis cause [–ATR]-spread constitute a natural class here in being | a |-specified. The high vowels /i/ and /u/ are opaque to | a |-

spreading because the combination that would result is ruled out by a "complexity condition" which disallows two dependents:

(53) NOT | x → a,i |

(The question as to whether this condition can be reduced to a government condition will be left unanswered here.) | a |, then, cannot associate to /i/ and /u/ and due to the locality of spreading (cf. section 5.1), | a | cannot spread across these segments.

4.1.3. Other cases

Goldsmith (1985) and Farkas & Beddor (1987), using different feature systems, argue that an analysis of Hungarian palatal harmony calls for reference to both values of the feature [back] ([u] in Goldsmith's system). Jensen & Stong-Jensen (1988) present an underspecification analysis of harmony in Hungarian in which the spreading values are [+back] and [−round], respectively. In section 2.2, I have sketched an analysis of Hungarian, which uses only "front" and "round".

Mester (1986, 1988) offers several analyses of harmonic processes which crucially refer to both values of features like [high] and [back]. In section 3, I have offered competing analyses of the same facts within the single-valued approach, showing that Mester's implicit claim that radical underspecification theory is wrong does not carry over to this feature system.

In the Pasiego dialect of Montañes Spanish a harmony rule adjusts non-low vowels to the height of a non-low stressed vowel (cf. McCarthy 1984, Vago 1988). This process, then, seems to refer to both values of a feature [high]. I have no reanalysis to offer here (cf. Smith 1987 for a discussion).

4.2. Reference to the "wrong" feature

Here I will discuss two cases which seem to be unanalyzable because at first sight our system lacks the appropriate feature. First, I will turn to a case which Hyman (1988) discusses, arguing that feature systems using | i |, | u | and | a | are inadequate. Then I will look at a case which involves both ATR-harmony and palatal harmony.

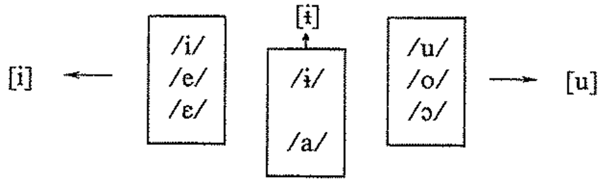
4.2.1. Esimbi

Hyman (1988) presents an analysis of vowel alternations involving height in Esimbi. Prefix vowels alternate as follows:

(54)	afx	i	e	ɛ
		u	o	ɔ
		o	ɔ/ɛ	a
	stem	i,u	i,u,ɨ	i,u,ɨ

(The ɛ-variant of the low prefix appears before [i].) Stems contain [i], [u], [ɨ], and, as will be clear, these vowels are ambiguous in their phonological behaviour. Hyman sets up three underlying vowels for [i] and [u] and two for [ɨ]. The underlying system then becomes:

(55)



Hence the conditioning of the alternant becomes phonologically natural:

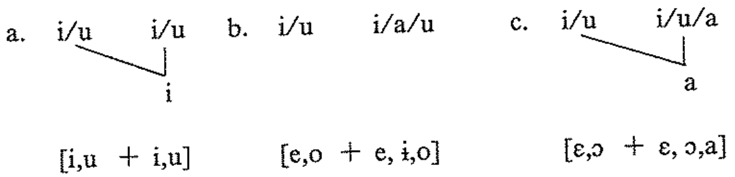
(56)	afx	i	e	ɛ
		u	o	ɔ
		o	ɔ/ɛ	a
	stem	i,u	e,o,ɨ	ɛ,ɔ,a

Hyman claims that an analysis of the alternations in terms of a single-valued feature system using | i |, | u | and | a | is problematical. I will show that this is not true, given the framework proposed here. For the sake of the argument, I will essentially accept Hyman's analysis of the root vowels. The central point of the alternative analysis concerns the phonological analysis of what Hyman calls the higher mid vowels (/e/, /ɨ/, /o/). In the analysis of Yoruba, I claimed that a comparable set of vowels should be analysed as [−ATR] high vowels, rather than, as is usual, as [+ATR] mid vowels. It appears that the same move can be made here (as Keith Snider has suggested to me).

Consequently, I will analyse the vowel system as follows:

(57)	/i/	/u/	/e/	/ɨ/	/o/	/ɛ/	/ɔ/	/a/
	i	u	i	a	u	i	u	a
	|	|				|	|	|
	i	i				a	a	a

The representation of the prefix vowels is simply | i |, | a | and | u |. The prefix vowels undergo | i | or | a | harmony:

(58)


In this framework we can translate Hyman's abstract analysis of the stem vowels into an analysis using floating features, i.e. stem vowels are characterized as | a |, | i | or | u |. In addition stems may have a floating dependent | i | or | a |, with the proviso that the dependent | i | cannot occur when the stem vowel is | a |, explaining why /ɨ/ is never a trigger for the high variants /i/ and /u/. As usual, then, there is no [+ATR] low vowel.

What remains to be accounted for is why the low vowel suffix ends up rounded before the high and the higher mid vowels (where we find it as /o/ and /ɔ/, respectively; cf. (56)) and why it is fronted to /ε/ before underlying /e/. For Hyman these events represent separate processes, so if they come out as distinct from the process of height transfer here as well, this will not reflect negatively on the present reanalysis. Having countered Hyman's claim, I will refrain from formulating these processes here.

4.2.2. *Koromfe*

Rennison (1987a) discusses various harmonic processes in Koromfe. On the one hand we find a rather regular [ATR]-harmony and on the other hand we find a harmony which involves a three-way alternation between /e/-/ə/-/o/ (and similarly: /ε/-/a/-/ɔ/). The latter type of harmony seems to involve the spreading of both | i | and | u |, and this of course (as Rennison, p.c., pointed out to me) is problematical for my earlier claim (expressed in Van der Hulst 1987) that palatal and ATR-harmony both involve spreading of dependent | i |. Koromfe has a ten vowel system of the familiar sort (cf. 12).

The three-way alternating suffix has to differ in terms of the governor feature, rather than the dependent feature, but since it is consistently non-high it has to be specified in terms of a dependent | a |. I therefore propose that the underlying representation of this suffix is as follows:

(59)


The shape of the three manifestations of this suffix results from spreading the governor features | i | (from /i/ and /e/), | u | (from /u/ and /o/) and | a | (from /a/). In the latter case I assume that the resulting | a→a | automatically reduces to | a |. Given this analysis there is no conflict in having ATR-harmony and palatal harmony within the same system.

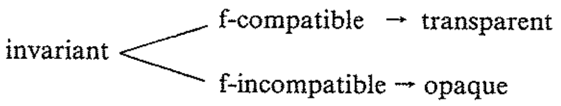
4.3. *Conclusions*

In this section we have looked at a wide variety of cases which appear, at first sight at least, problematical for the feature system proposed here. In all cases it has been shown that there is in fact a possible analysis which straightforwardly deals with the data. Interestingly, in many cases the solution depends on the possibility of representing high mid vowels as either non-ATR high vowels or ATR mid vowels.

5. OPACITY AND TRANSPARENCY

In the discussion of vowel harmony systems I have not paid systematic attention to the behaviour of non-alternating or invariant vowels. In Van der Hulst & Smith (1986a) it is suggested that transparency or opacity can be predicted on the basis of the feature specifications of the vowels in question. In this section I wish to show that this proposal carries over to the present system, but I will also point out some problematic cases (discussed in Van der Hulst & Smith 1986b), which I cannot all solve satisfactorily at present.

As formulated in Van der Hulst & Smith (1986a), transparency typically arises when an invariant vowel is compatible with the spreading value in the sense that it has this value lexically (because it is distinctive) or that it will acquire this value through a redundancy rule (because it is non-distinctive and predictable). Opacity, on the other hand, will arise if a vowel is incompatible with the spreading value, because it (distinctively or non-distinctively) lacks this value on the surface:

(60)


The "translation" of this generalization about transparency to a system making use of governors and dependents will say that a segment S will be transparent to f-spreading if the governor-specification of S is compatible with f (cf. Demirdache 1988 for a similar approach) and opaque if the governor-specification is incompatible with f. I will now discuss both possibilities in some detail and I will go through the various possibilities according to the following schema:

(61)

1.	f-compatibility	5.1.1	Expected transparency
		5.1.2	Unexpected opacity
2.	f-incompatibility	5.2.1	Expected opacity
		5.2.2	Unexpected transparency

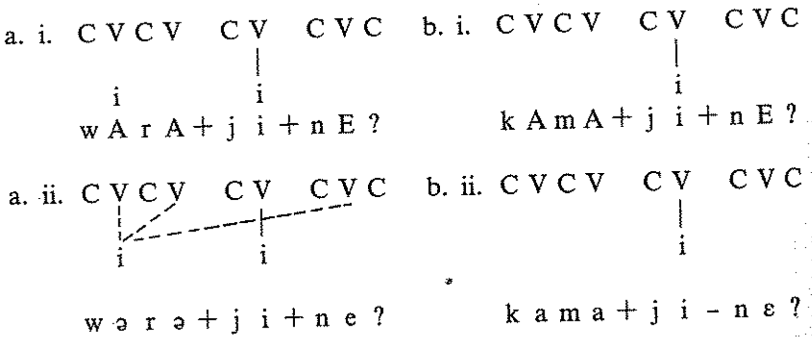
In each category I will first discuss distinctive and non-distinctive (in)compatibility, in that order. As will become clear, for some of the logical possibilities we have only a small empirical basis for knowing what the behaviour of the invariant segments will be, and in other cases we have no empirical basis at all. For this reason alone, the contents of this section specify a research programme, indicating which cases have to be considered, rather than anything else. Here I have not considered the issue of intervening consonants, which would obviously be part of such a programme.

5.1. F-compatibility

5.1.1. Expected transparency

Distinctive f-compatibility. Consider ATR-harmony in Bari, which has a tenvowel system divided into two sets of five vowels. Suffixes alternate in accordance with the ATR-specification of the root. Hall & Yokwe (1978) report that certain suffixes invariantly show up with a high ATR vowel. When another suffix occurs after them the vowel of this suffix will be ATR if the stem is ATR, but it will be non-ATR otherwise. Thus the high invariant vowels show typical transparent behaviour. On the assumption that there also exist high vowel suffixes which do show an alternation, Van der Hulst & Smith (1986a) argue that the ATR quality of the high vowels cannot be predicted, so that these vowels must be specified as ATR lexically:

(62)

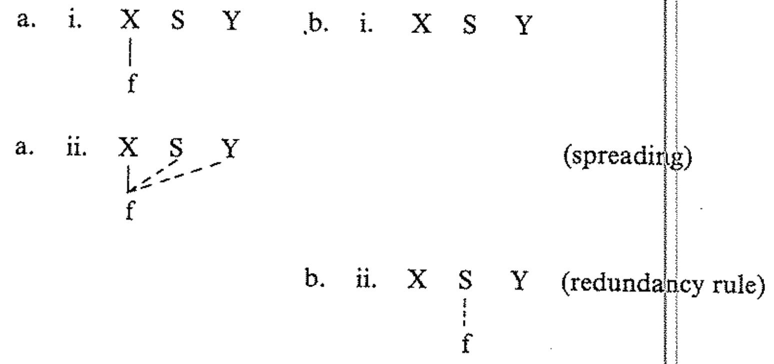


We must assume that the floating feature of the stem spreads rightwards

through the association line connecting | i | to the invariant suffix vowel. Since we know that all vowels are potential triggers, one might ask how we prevent the lexically specified f from spreading. It seems that we have to mark such vowels as non-triggers, which is not very attractive. Cole & Trigo (1987) claim that transparent vowels can always be assigned f by a redundancy rule, also in Bari. If they are right it will never be the case that targets distinctively bear f without spreading it. Support for this comes from a comparable case, where we do find that invariable suffixes cause spreading. For example, in Turkish we find high suffix vowels which are invariably rounded. These suffixes induce rounding on subsequent high suffixes.

Non-distinctive f-compatibility. This is the typical case of transparency. S will usually have a governor specification from which the presence of f can be predicted. If S occurs in a domain which contains no instance of f, it will still show up with f through the application of a redundancy rule:

(63)



Under this analysis "transparency" is a surface effect, resulting from the fact that the "transparent" vowel is flanked by vowels surfacing with the "default value". I will simply mention a number of cases illustrating this kind of transparency, which the reader may check at his or her own leisure in the literature mentioned here:

- | i |. The front unrounded vowels, /i/ and /e/ in palatal systems of Finugric languages represent a well-known case of transparency. These vowels lack a harmonic counterpart (cf. sections 2.1.2 and 2.2); on the surface they are | i |-specified, but this specification is non-distinctive and therefore predictable. Also, in ATR-systems as that of Khalkha the transparency of /i/ is in line with this proposal (cf. Van der Hulst & Smith 1988). African ATR-systems as in Tunen show examples of invariant ATR-specified vowels /i/ and /u/ which fail to initiate ATR-spreading themselves and which are transparent with respect to a preceding trigger (cf. Van der Hulst & Smith 1986a, Van der Hulst, Mous & Smith 1986a).

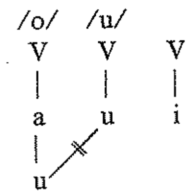
- | a |. The transparency of certain schwas in Chukchee, which on the surface (in our analysis) end up with | a |, is in line with the present proposal (cf. section 2.3).
- | u |. With respect to labial harmony, I am not aware of any examples illustrating transparency, but the claim is that transparent vowels would have to be rounded.

Vowels having the spreading f as a redundant property, acting transparently as predicted, can sometimes trigger harmony, either from certain positions (initial /i/s in Khalkha) or in particular morphemes (so-called neutral vowel roots in Hungarian). This behaviour does not contradict what we have stated so far. The point is that compatible invariant vowels may simply occur in a triggering context. Obviously, if the triggering context merely contains front/ATR vowels the natural situation is one in which the redundant value of these front/ATR vowels is spread.

Before we turn to f-incompatibility, let us contemplate the following question. Are there cases of non-parasitic harmony involving intervening f-compatible vowels which are not triggers and which are also excluded as targets? Here I will argue that there are no such cases. To see this clearly, let us establish what they would look like.

Assume a vowel system as in (64b). Suppose we have a rounding harmony operating from low vowels to front high vowels only. In such a case the high back vowels constitute non-targets and the question is what the behaviour of a /u/ will be, intervening between a trigger and a target:

(64) a.



b. /i/ /y/ – /u/
/e/ /ö/ /a/ /o/

Given our findings so far, we expect /u/ to be transparent. I would now like to suggest that in situations of this type it is indeed impossible to mark /u/ as a non-target, simply because there is no independent way of telling that this would be the case; i.e. /u/ does not belong to a larger class of vowels such that it can be established for this class that its members are non-targets. Note that if f-compatible non-trigger, non-target vowels could exist, we would expect them to be opaque, given the locality dictum (cf. below). A dramatic consequence of this would be that we would no longer be able to predict when tranparency arises. In other words, we would allow a language, say Hungarian', in which /i/ and /e/ are opaque. I therefore conclude that the notion of negative target does not, and cannot, apply to f-compatible vowels (distinctive or non-distinctive), which means that we can maintain that such interveners are transparent unless the harmony is parasitic on a property which the intervener lacks.

5.1.2. Unexpected opacity

In a number of cases vowels which non-distinctively have f and which, according to the above, should therefore behave transparently, fail to do so. In this category we find no cases involving distinctive f-compatibility. In all three cases the interveners have the spreading feature as a governor, which implies that they will acquire this feature by virtue of the universal redundancy rule.

Vowels non-distinctively bearing f can be opaque, not in the sense that they can initiate a new harmonic span, but because they simply block f-spreading. Such behaviour is known to us from a few cases, of which we mentioned one earlier, i.e. the case of | u |-spreading in Khalkha, which is blocked by the intervening high rounded vowels /u/ and /y/. Another example involves | a |-spreading in Bantu languages, of which no example has been discussed, in which case a low vowel /a/ acts opaquely (cf. Rennison 1987b). A third example involves lax /ɛ/ in Menomini, which has been reported to be opaque with respect to | a |-spreading (cf. Cole & Trigo 1988).

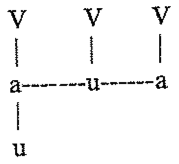
How can we account for this blocking behaviour? I tentatively offer the following explanation. In at least two of the cases mentioned we seem to be dealing with instances of parasitic harmony. In Khalkha | u |-harmony is parasitic on | a |, whereas in Menomini | a |-harmony is parasitic on "tense". Cole & Trigo (1988), who discuss the case of Menomini, and Van der Hulst & Smith (1988), who discuss Khalkha, have argued that blocking effects arising in cases of parasitic harmony have nothing to do with the "(non) f-hood" of the blockers, but result from their missing the feature on which f-spreading is parasitic. Whether harmony in Bantu extensions can be analyzed in a similar vein remains to be investigated; the fact that such harmony is limited to non-low or mid vowels is encouraging.

Let me illustrate the opacity of /u/ and /ω/ in Khalkha. The vowel system of Khalkha is as follows (cf. Van der Hulst & Smith 1988):

(65)

/i/	/u/	/ω/	/e/	/o/	/a/	/ɔ/
–	u	u	a	a	a	a
	i		i	u,i		u

(66)



Here the first and third segments are not adjacent with respect to the governing feature | a | and we see that parasitic spreading is blocked.

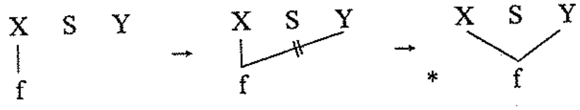
Note that, as said, in cases of this type the intervening vowel is non-distinctively f-compatible. For example, we have no case of an /y/ (contrastive with /i/) blocking rounding harmony going from /ö/ to /e/, where the rounding harmony is parasitic on | a |. Khalkha has been claimed to be of this type, but if /y/ is an advanced /u/ rather than a rounded /i/, this is a different case.

5.2. *F-incompatibility*

As stated above, Van der Hulst & Smith (1986a) observe that f-incompatible invariant vowels typically are not transparent in harmony systems. This means that in ATR-systems [–ATR] vowels will be opaque; in | a |-systems, high vowels will be opaque and in | u |-systems unrounded vowels will be opaque.

The most natural assumption is indeed that incompatibility leads to opacity, because otherwise harmonic spans arise which are phonetically discontinuous. We can express this as follows. Assume f cannot associate to S because of incompatibility:

(67)



Discontinuity is ruled out if we stipulate that the second step in (67) is blocked on universal grounds: all spreading is local (cf. Archangeli & Pulleyblank, in press, Van der Hulst & Smith 1986a).

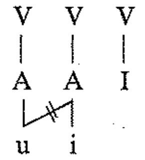
F-incompatiblity may be the result of a negative condition, in which case we deal with distinctive f-incompatibility, or a governing or complexity restriction, in which case non-distinctive f-incompatibility is involved.

5.2.1. *Expected opacity*

Distinctive f-incompatibility. Opacity due to a negative condition occurs in Hungarian and Kalenjin. Here, as we discussed in section 4.1.1, certain vowels fail to undergo either rounding harmony or ATR harmony, which cannot be explained by suggesting that there is some restriction ruling out the intended association; the result of association would lead to a wellformed vowel of the language. In this case, then, these vowels lack f distinctively and they simply cannot associate to it on morpho-lexical grounds. The important point is that such vowels act opaquely. This behaviour follows because the spreading feature cannot associate with the vowels due to the negative condition and the fact that it cannot be skipped due to the locality dictum. We can deal with opacity in disharmonic roots in the same way. Here, too, certain vowels resist harmonizing despite the fact that they have a harmonic counterpart in the system.

Negative targets also fall in this category. In many Turkic languages it is the case that in the rounding harmony system a subclass of vowels does not undergo the rounding harmony process. An example is furnished by Turkish rounding harmony. Here low vowels do not undergo rounding harmony, not because there is a government restriction, but because low vowels are excluded as targets; they are negative targets lacking f distinctively, because they have rounded counterparts in the vowel system. Since low vowels in Turkish behave opaquely we may conclude that negative targets are "opaque".

(68) a. /o/ /e/



b. /i/ /y/ /ɨ/ /u/
/e/ /ö/ /a/ /o/

Non-distinctive f-incompatibility. This represents the typical case of opacity. Again, I will simply list a range of examples.

- A typical example of opacity involves ATR-spreading in systems which lack an ATR low vowel. Typically invariant non-ATR vowels are opaque in such systems. Other examples of the same opacity effect, also involving | i |-spreading, occur in Votic and Rumanian, which have palatal harmony. Votic has a system like Finnish, but in non-initial syllables there is no /ö/ (cf. Harms 1987). In other words, there is a restriction preventing | i | from associating with /o/ in non-initial position. As expected such /o/s block palatal harmony. Rumanian lacks fronted counterparts of /u/, /o/ and /a/ which, as expected, act opaquely with respect to palatal harmony (as reported in Steriade 1986).
- The opacity of Middle Korean /i/ vis-à-vis | a | might be included here if we assume that a government restriction blocks | a | from associating to | i |. Another example of opacity in an | a |-system occurs

in Yoruba, where the high vowels /i/ and /u/ resist | a | (cf. section 4.1.3).

- Opacity in | u |-systems is attested in Bashkir, which has rounding harmony. Here low vowels block rounding harmony among mid vowels (Poppe 1962). High vowels occur only in initial syllables. They do not trigger rounding harmony. There is a restriction ruling out low rounded vowels. Hence low vowels are opaque with respect to | u | harmony. Another example is found in Chumburung (Snider, forthc.), where /a/, which lacks a rounded counterpart, is opaque with respect to roundness harmony. Finally, in Tungusic languages /i/, which has no rounded counterpart, blocks | u |-spreading.

Interestingly, the opacity effects could in some of these cases be attributed to the parasitic nature of the harmony. I.e., rounding harmony in Bashkir and Chumburung or ATR-harmony among non-low vowels can be seen as parasitic. In fact, Cole & Trigo (1988) seem to suggest that all opacity arises from elements which prevent parasitic harmony from applying. The opacity of Votic /o/, however, cannot be attributed to this factor, so I will assume that there are independent reasons for explaining opacity in terms of f-incompatibility of targets.

5.2.2. Unexpected transparency

There are a few cases which suggest that harmonic spans can be discontinuous. In these cases we get non- | i |, non- | a | and non- | u | vowels which fail to be opaque and hence occur inside a harmonic | i |, | a | or | u |-span. The relevant cases known to us are the following.

- Schlindwein (1986) analyses a case in which the low vowel /a/ in an ATR system acts transparently. It seems not unlikely, however, that in this case the low vowel turns into an ATR vowel under such circumstances, which implies that there is harmonic continuity. We could perhaps deal with such a case by assuming that the relevant government restriction only holds with respect to the underlying lexical representations. Although a language might not have a phonemic distinction between /a/ and /ə/, it might still allow ATR-harmony to apply to the low vowel deriving an allophone. Harmony in this case is not structure-preserving. This could apply to the case discussed in Schlindwein (1986). We cannot maintain that all harmony is structure-preserving, as is shown by Harris (1987) and also by our discussion of Chukchee in section 2.3.

There are, however, also a few cases of unexpected opacity where the intervening transparent vowel shows no phonetic effect when occurring in a disharmonic context:

- In Eastern Cheremis certain suffixes show a three-way alternation conditioned in the following way:

(69)

sfx	e	ö	o
stem	i,e,a	y,ö	u,o

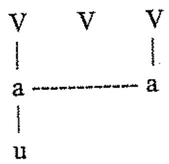
The point here is that the choice of one of the alternants is determined by a preceding vowel. If the preceding vowel is schwa, however, the next preceding vowel is the determinant. If there are no vowels but schwa's the suffix vowel is /ə/ (cf. Sebeok & Ingemann 1961:101). What we see here is transparency of schwas both with respect to | i |-spreading and with respect to | u |-spreading.

The most celebrated examples falling in this category involve the /i/ in both Khalkha | u |-harmony and Nez Perce | a |-harmony.

- The problem in Nez Perce can be solved by assuming that the representation of /i/ is actually | y → a |. Triggering /i/ has this representation underlyingly, whereas transparent /i/ is incompletely specified as | y |. Both end up as | i → a |. This boils down to saying that Nez Perce /i/ is phonologically a mid vowel. If this can stand, | a |-spreading is not discontinuous.
- In Khalkha, /i/ does not interrupt | u |-spreading, while the rounded high vowels do. /i/ non-distinctively lacks | u |. This is true if we assume that /y/ is not to be analyzed as a rounded /i/, but rather as an advanced /u/ (cf. Svantesson 1985). How can we account for this behaviour? A solution to the problem could be to argue that the intervening /i/ is completely unspecified (lacking even | y |), a position taken by Archangeli & Pulleyblank (in press). Being completely unspecified a vowel will not be "visible" for the spreading feature (i.e. it has no anchor for vocalic features) and thus the continuity hypothesis is preserved, not at the phonetic level, but at a more abstract phonological level.

By assuming that /i/ is unspecified we can simply say that rounding harmony is fully parasitic on | a |-identity (cf. (64-65) above and also Goldsmith 1985):

(70)



Note that in the cases of unexpected transparency discussed here the f-incompatibility is non-distinctive. I.e. we have no case in which, for example, /i/ (contrasting with /y/) acts transparently in a rounding harmony system.

The escape route using completely unspecified vowels introduced to deal with cases of unexpected transparency can in principle also be applied to a subset of the cases of expected transparency. For example, Hungarian /i/ might be argued to be empty. We must still appeal to f-compatibility as a source for transparency, however, since in Hungarian /e/ is transparent too. Obviously we cannot assume that both /i/ and /e/ are completely unspecified. (This is parallel to the point that the account of unexpected opacity in terms of parasitic harmony applies to a subset of the expected opacity cases as well.)

5.3. Conclusions

My main concern here has been to discuss systematically the conditions under which non-alternating (intervening) segments can appear and to suggest principled ways of accounting for their behaviour under these conditions. Concluding, one might say that the correlation noted in Van der Hulst & Smith (1986a,b) between the behaviour of invariant vowels holds except for a few examples. I have argued that unexpected opacity arises only when the harmonic process is parasitic, whereas unexpected transparency involves a completely unspecified intervener, at least in some cases.

6. CONCLUSIONS

An idea which has guided much recent work in feature theory is that markedness considerations should be "built in" in the formalism for expressing phonological rules and representations. The use of single-valued features represents an attempt to express directly the notion of marked value introduced in Prague-school phonology. However, markedness not only involves the "context-free" phenomenon that in the case of a binary opposition one value is marked, but it also involves "context-dependent" phenomena such as the fact that backness and roundness or highness and ATR-ness go together in the unmarked case. The present proposal represents a natural extension of this research programme, since it is an attempt to build the latter type of markedness into the notation.

Applying the proposal to a wide variety of harmony systems has led us to propose additional principles. Because I have chosen to avoid in-depth case studies here, basing myself in a few cases on very limited data reports, some of these additions have to be regarded as rather tentative. Still, I have tried to be as explicit as possible, drawing attention not only to what I believe to be the strong points of the proposal but also to aspects which certainly need further study.

NOTE

[*] The central ideas behind this model were first presented in Van der Hulst (1987), which includes a preliminary version of sections 2 and 3 of the present paper. Van der Hulst (forthc. a) gives a condensed version of these two sections. A follow-up to the present paper is Van der Hulst (forthc. b). I wish to thank the following colleagues for useful comments on this paper: Marcel den Dikken, Colin Ewen, Teun Hoekstra, Michael Moortgat, Maarten Mous, Martina Noteboom, Iggy Roca, Thilo Schadeberg, Norval Smith and Keith Snider. All mistakes and inconsistencies are my own.

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