

On Neutral Vowels

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0. Introduction*

We speak of *harmony* when phonological segments which belong to a domain D and which share a set of properties A must also agree in their specification for another set of properties B. A common type of harmony is *vowel harmony*. In many languages we find that all segments which belong to the same morpheme or word and which share the property of being a vowel agree with respect to another feature such as for example backness. In the simplest case all vowels

in D will be either front or back.

The "simplest case" of vowel harmony just referred to involves a situation in which there are two non-overlapping sets of vowels (e.g. back vowels and front vowels), i.e. each element in one set has a *harmonic counterpart* in the other set and only vowels which belong to the same set co-occur. Typically however actual cases are not so simple. We distinguish at least two circumstances which complicate a vowel harmony system.

The first circumstance arises if the two sets of vowels intersect, resulting in a situation that some vowels have no harmonic counterpart. One can say that segments which occur at the intersection of the two sets have a predictable value for the *harmonic feature*. In the literature such vowels are often called *neutral*, but one must be careful to distinguish two kinds of neutral vowels. In one type of case the neutral vowels appear to be *transparent* in the sense that the harmonic requirement, as it were, looks right through them, i.e. vowels occurring to their left must harmonize with vowels to their right (and vice versa), just as if the neutral segments were not there. Suffix vowels which are adjacent to a transparent vowel occurring in the final syllable of a stem harmonize with the first non-transparent vowel to its left, ignoring the fact that the transparent vowel intervenes. In the other type of case the neutral vowels are *opaque*, i.e. it is not necessary that vowels occurring on either side harmonize with each other. Also, suffix vowels which are adjacent to an opaque vowel harmonize with it.

The second circumstance arises if a harmony system is "obscured" by the presence of vowels which, although they do have a harmonic counterpart and hence do not have a predictable value for the harmonic feature, still fail to harmonize, either in particular morphemes, or everywhere, and again such segments may behave as transparent or opaque. Vowels of this type then are neutral without there being a neutralization of an opposition. For want of a better term we will refer to such vowels as *pseudo-neutral* segments in those passages where we explicitly want to distinguish between them and the neutral segments discussed in the previous paragraph.

In agreement with the traditional literature we will use the term neutral segment in the general sense: a segment which is either transparent or opaque is called neutral.¹ In the course of this article we will introduce some additional terminology. We will make a distinction between *accessible* and *inaccessible* vowels. Inaccessible vowels can properly be called opaque, but the set of accessible vowels will comprise both the so-called transparent vowels and

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This article deals with the question how harmony systems which divert from the "simplest case" are to be analysed in an autosegmental framework. In particular we will concentrate on the treatment of neutral segments, and limit our discussion to vowels in the main. From the outset, opaque and in particular transparent vowels have been problematic for earlier versions of autosegmental phonology. As a critical feature of this model in its standard version we take the fact that each feature is represented on one tier only. Non-standard versions (as proposed by Hart (1981), Van der Hulst & Smith (1982), Booij (1984), Ewen & Van der Hulst (1985), Hermans (1985), Vago (in prep.)) allow for the possibility of specifying a single feature on more than one tier. In all the publications mentioned it is proposed that segments which are transparent are *segmentally specified*, such that an autosegment can spread across them. In addition to this, Vago argues that the treatment of opaque segments also calls for an increase in the number of tiers on which one and the same feature may be specified. We will discuss other treatments of transparent segments, such as those proposed in Clements (1976, 1977), Van der Hulst (1985) and Goldsmith (1985) and other ways of dealing with opaqueness, such as those proposed by Clements (1976, 1981) and Pulleyblank (1985a). We will conclude that both transparency and opaqueness can be dealt with without giving up the idea that there is only one tier for each feature: We will argue that the relation between elements on a tier and skeletal points can be of three types. Firstly, an autosegment can have a skeletal point within its scope without being associated to it; secondly, an autosegment can be associated to a skeletal point. In that case we will say that this point is *inherently specified*. And, thirdly, an autosegment can be bound to the domain consisting of a single skeletal point (which we will refer to as a *segmental domain*). In that case the autosegment is *segmentally bound*.

A related question that we will focus on is whether or not a relationship can be established between the behaviour of neutral segments as either transparent or opaque and *markedness theory*. As we will see, neutral segments may have either value of the harmonic feature, i.e. in harmony systems based on the feature [Advanced tongue root] ([ATR]) neutral segments may either be [+ATR] or [-ATR]. It will appear that neutral vowels which are [+ATR] may be either transparent or opaque, whereas those which are [-ATR] are always opaque. A comparable situation may exist in front-back harmony systems, where neutral segments may be [-BACK] or [+BACK]. The data available to us suggests that in systems of this type front neutral segments may be either transparent or opaque,

whereas back neutral segments may only be opaque. To explain these asymmetries we will adopt a theory of phonological features in which the "plus" and the "minus" values play a different role in the sense that one is considered to be the marked pole (literally), whereas the other is the unmarked pole. These ideas were introduced into autosegmental theory in Halle and Vergnaud (1981) and further exploited in Kiparsky (1982, 1985), Kaye (1982), Pulleyblank (1983) and Archangeli (1984). We will adopt a version of this approach in which the so called marked pole is represented by the presence of a (single-valued) feature, whereas the unmarked pole is represented by the absence of this feature. Within this approach then relations between harmonic grades are interpreted in terms of *privative* relations in the sense of Trubetskoy (1939). In adopting a *single-valued feature theory*, we follow work in Dependency Phonology (cf. Anderson and Ewen (to appear)) and other current work (Kaye, Lowenstamm & Vergnaud (1985), Goldsmith (1985), Rennison (1985), Van der Hulst & Smith (1985), Ewen & Van der Hulst (1985)).

This article is organized as follows. In section 1, we will discuss the possibility of combining a number of proposals and insights expressed in the recent autosegmental literature, which are directly or indirectly intended to solve the problem of explaining the behaviour of neutral vowels. We will conclude that these current views dealing with neutral segments must be modified somewhat in order to arrive at a consistent approach. In section 2 we provide (partial) analyses of vowel harmony systems which illustrate the behaviour of neutral segments, in particular those of the second type mentioned above, i.e. the pseudo-neutral vowels. The systems in question have recently been analysed by Vago and Leder (to appear) and Steinberger and Vago (to appear). Our secondary purpose is to show that these systems do not support any of the claims that these writers make concerning the necessity of representing one and the same autosegment on different tiers. Limitations of space prevent us from providing a full scale comparison between our approach and that of Vago and his collaborators.

1. Approaches to neutral segments

1.1. The standard model

In several papers Clements has proposed extending autosegmental phonology, which was originally proposed as a model for describing tonal phenomena, to

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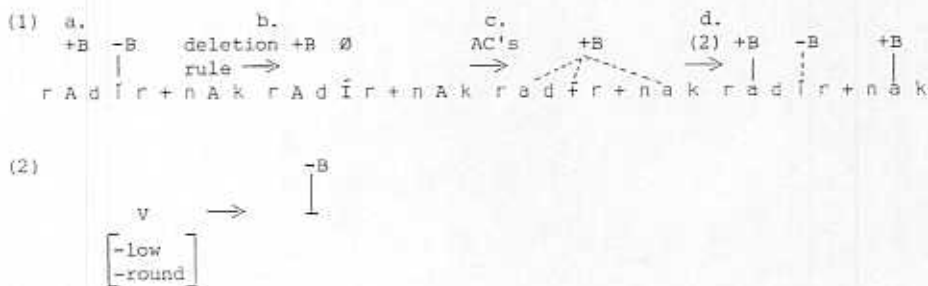
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cover harmony phenomena (Clements (1976, 1977, 1981), Clements and Sezer (1982)). We will delineate here how transparent and opaque segments were analyzed within this approach.

As an example of the treatment of transparent vowels we may consider Clements' (1977) analysis of Hungarian vowel harmony.² This system is based on the feature [Back]. Non-low, unrounded vowels (/i/ and /e/, both long and short) are transparent: the vowels occurring on either side must agree in their value for backness.³

In Clements' original proposal transparent vowels occurring in roots are associated to [-B]⁴ before the working of the universal association conventions (henceforth AC's).⁵ Subsequently the autosegment associated with non-low unrounded vowels is deleted if it follows a [+B] autosegment (as in (1a)). Then the AC's apply and non-low unrounded vowels go through an "abstract" stage: when occurring in a back vowel root they become associated to the autosegment [+B] by the AC's, which results in [+i] or [+e], vowels which do not belong to the Hungarian surface vowel inventory (as in (1c)). After the working of the AC's an absolute neutralization rule, given in (2) (which is identical to the redundancy rule mentioned in fn. 4) applies turning [+i] and [+e] into [i] and [e] (as in (1d)). The derivation of *radír* 'eraser (dat.)' illustrates the steps just mentioned:⁶

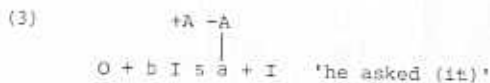


It may seem as if the first two steps could be eliminated. Clements assumes that transparent root vowels are linked to [-B] in the first place, because if no floating [+B] co-occurs in the root (i.e. if the roots contains only neutral vowels) suffixes regularly show up as front, showing that front vowels in roots must co-occur with a [-B] autosegment to begin with.⁷

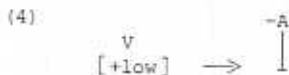
There is no comparable evidence to assume that neutral vowels in suffixes are linked to [-B].

The treatment of opaque segments is as follows. As an example consider Clements' (1981) analysis of vowel harmony in Akan. This system is based on [ATR]. There are nine vowels (/i,u,e,o/ vs. /ɪ,ɔ,ɛ,ɔ,ə/). The low vowel is always [-ATR]. It is clear that the low vowel is opaque: vowels to its left and right may differ in value for [ATR].

In Clements' proposal, an opaque vowel is linked to its autosegmental value before the AC's apply:



The predictability of the linking of [-A] to the low vowel is expressed in a redundancy rule (RR) which applies before the AC's:



Given the prelinking of [-A] to the low vowel, the floating [+A] in (3) cannot be linked to the second root vowel because the AC's cannot associate [+A] to a vowel already linked to another autosegment, i.e. they only apply to free vowels. Due to the universal convention that association lines may not cross, the floating [+A] cannot be linked to the suffix vowel either, which is then linked to [-A]. The result of applying the AC's to (3) is:



Opaque segments are then *blockers*, *non-undergoers* and *spreaders* (cf. Clements and Sezer (1982)).

We will now mention briefly a number of ideas and proposals which have found their way into recent versions of autosegment phonology, and which, if correct, must be combined. We will discuss one such combination, and then mention a number of problems which eventually lead us to propose another "integrated" model.

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1.2. Modifications

1.2.1. Underspecification

In many phonological models, it has been assumed that predictable feature values are not specified in the lexical representation. Rather they are filled in by rule. Usually such values are referred to as *redundant values*, and rules which fill in these predictable values are referred to as *redundancy rules*. The various models differ with respect to the point in the phonological derivation at which redundant values are filled in. The viewpoint in Chomsky and Halle (1968) is that redundant values are filled in before phonological rules start applying.

The idea behind saving on redundant values is twofold. On the one hand leaving out these values attributes to the economy of the lexicon, and on the other hand stating rules which fill in these values allows us to capture generalizations concerning the sound structure of a language. In work building on Chomsky and Halle (1968, Chapter 9), Halle and Vergnaud (1981) and especially Kiparsky (1982), a somewhat different way of motivating underspecification has emerged. If one assumes that each feature is universally supplied with a *unmarked value* one can maximize the economy of the lexicon, by leaving unspecified all occurrences of this value. At some point in the derivation unmarked values will be assigned in each case where a value is still lacking. The rule which fills in the unmarked value, which we will call a *default rule* (DR), does not express a generalization about the structure of a particular language, rather such a rule embodies a claim about the relative markedness of feature specifications.

In the above mentioned works it is assumed that the marked value is the only one specified in the lexicon. We will say that it functions as the *lexical value*. In Archangeli (1984) it is argued in addition that it may be necessary to assume that for a particular feature the unmarked value, rather than the marked value, is lexically specified in some language. Let us refer to this as *markedness reversal*. Actual underspecification, she argues, is primarily based on the language-particular behaviour of segments. In such cases of markedness reversal the unspecified value must not be filled in by the universal default rule, but by a rule which has the opposite effect. Such rule is termed a *complement rule* (CR) by Archangeli.

It is well-known that allowing "blanks" in phonological representations may lead to a feature system in which features have three values. Archangeli claims that in the approach just sketched this doesn't happen since for any feature

we specify either "+" and "0" or "-" and "0", where either "+" or "-" is the lexical value. Below, we will briefly come back to this point.

We don't always have to specify all occurrences of the lexical value, since even some of these may be predictable on the basis of a language-particular redundancy rule:

- (6) Lexicon: $\begin{matrix} [+F] \\ [OF] \\ [OF] \end{matrix}$ vs. $\begin{matrix} [OF] \\ [+F] / X \\ [-F] \end{matrix}$
 (Redundancy rule (RR): $\begin{matrix} [OF] \\ [OF] \end{matrix} \rightarrow \begin{matrix} [OF] \\ [+F] / X \end{matrix}$
 Default/complement rule (D/CR): $\begin{matrix} [OF] \\ [OF] \end{matrix} \rightarrow \begin{matrix} [OF] \\ [-F] \end{matrix}$

The combined hypothesis to eliminate both redundant and default/complement values from lexical representations is referred to as the *underspecification hypothesis* (UH).

With respect to the issue of filling in feature-values, the following viewpoint is expressed - restricting our attention first to default and complement rules (cf. Pulleyblank (1983), (1985b), Archangeli (1984)):

- (7) a. D/CR's begin their application in the latest possible stratum⁶
 b. D/CR's apply as early as possible within their stratum
 c. A D/CR assigning [αF], where "α" is "+" or "-", is automatically assigned to the first component in which there is a rule that refers to [αF]

What about redundancy rules, i.e. rules which assign the lexical value in those environments where it is predictable? Pulleyblank argues that RR's will apply at the lexical stratum, before any phonological rules apply. This is so, since, as is argued in Kiparsky (1982), lexical entries can be seen as rules. If this is a correct point of view, the presence of the lexical value in these "rules" will trigger the application of redundancy rules in the lexical stratum, according to (7c). We believe that the logic of this argument is sound. Below, we will show that this point leads to an important problem for an otherwise attractive treatment of transparent segments which is proposed by Goldsmith (1985).

The effect of the conventions in (7), in particular (7c), is "to divide a derivation into two stages: a. an initial, underspecified stage where phonological rules can distinguish between non-redundant specifications and the absence of specifications, and b. a subsequent, fully specified stage where phonological rules can distinguish between "+" and "-." Convention (7c) then "rules out a stage in the derivation where it would be possible to refer to

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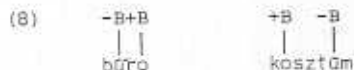
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a lack of specification for feature F while also being able to refer to both "+" and "-" values of F." (Pulleyblank (1985b), p.6/7).

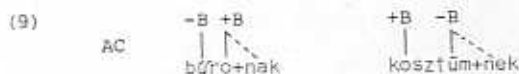
The UH accounts for the fact that the plus and minus value of phonological features are not "equal". A more "drastic" way to account for this asymmetry would be to say that phonological features are in fact single-valued. Although the single-valued feature hypothesis (SVFH) and the UH come very close in their claims, there are of course significant differences. Presumably the SVFH makes markedness reversal impossible, i.e. proponents of the SVFH do not assume that it depends on the language in question whether the positive or the negative pole functions as a single-valued feature. A second important difference is that the SVFH claims that default values are part of the phonetic component. Thus it also makes the prediction that rules which manipulate default values must be phonetic (and post-lexical). In sect. 1.4.1. we present some arguments in favor of the SVFH. In the meantime we will utilize a binary feature system.

1.2.2. Disharmonic roots and the strict cycle condition

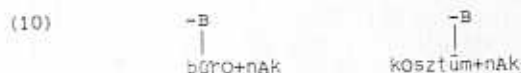
If we allow only one value to appear in the lexicon a particular problem arises when we are dealing with a system possessing *disharmonic roots*. Consider the following example from Hungarian. Words like *büro* or *kosztüm* are disharmonic in that they contain both non-neutral front vowels and back vowels. The analysis of such cases proposed in Clements (1977) is the following:

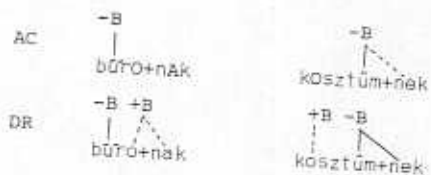


Suffix vowels harmonize with the last root vowel:



This approach is not compatible with the UH. Assuming that [-B] is the lexical value (this will be motivated in the next section), only the following representations will be allowed:





In both (8) and (10) either all or some root vowels are formally represented as opaque. The problem with the representation in (10) is that we must prevent the [-B] autosegment from spreading to the free root vowel.⁹

This problem is discussed in Levergood (1984) with respect to a similar situation in Maasai, and she argues that spreading is prevented by invoking the *strict cycle condition*. For the purposes of this article we give the following ad hoc formulation of the SCC:

- (11) **Strict Cycle condition (SCC)**
 The AC's may only associate an already associated autosegment to a free vowel if the configuration which triggers application is derived

As it is stated here this condition forces us to assume, (as is usual, cf. Clements (1976)), that the autosegment of harmonic roots is floating. If the floating autosegment is associated to the first vowel (which is allowed since the autosegment isn't associated yet at this point) it will no longer be floating. The configuration resulting from the first application of the AC's is (*phonologically*) derived and therefore the process of association may continue. In the case of (10) spreading of the lexically associated [-B] to the root vowels would involve a non-derived environment, whereas spreading to the suffix vowels involves a (*morphologically*) derived environment. The latter is allowed by the SCC, the former is not.¹⁰

1.2.3. *Transparent segments*

In the analysis of front-back vowel harmony systems, Goldsmith (1985) selects (a feature indicating) frontness as the lexically specified value. As we have seen in sect. 1., Hungarian, which is a system of this type, has neutral front vowels which behave transparently. By assuming that front is also the lexical value, Goldsmith arrives at a maximally simple analysis of transparent vowels.

The following schematic analysis of Hungarian vowel harmony captures the spirit of Goldsmith's proposal. It is not identical to it. Below in sect. 1.2.5. we will enumerate a number of problems for the approach to transparent vowels which is inspired by Goldsmith's proposal. One should therefore keep in mind

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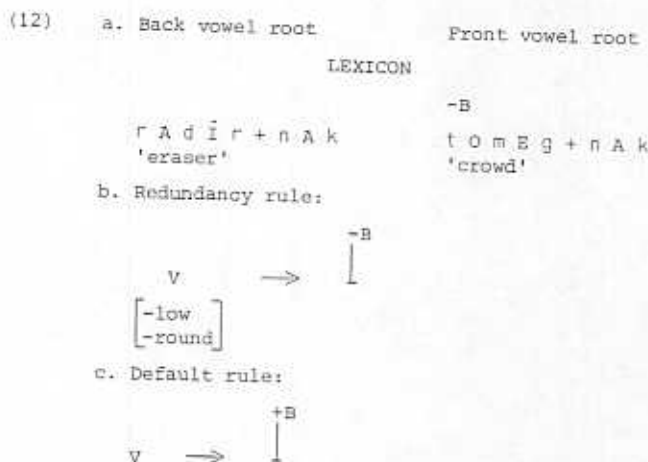
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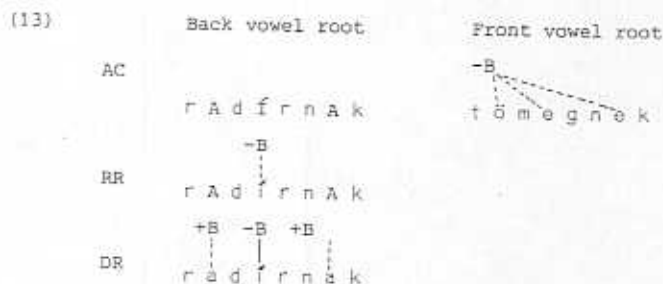
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that Goldsmith's analysis is different from what we discuss here.¹¹

Transparent vowels may occur in back vowel roots, front vowel roots and neutral vowel roots. Let us first discuss the first two cases. In (12a) we represent the lexical entries for both cases and in (12b,c) the necessary RR and DR:



The redundancy rule (RR) is more specific than the default rule (DR) and is applied first as predicted by the Elsewhere Condition, which we assume to be correct without motivating that here.¹² Prior to the application of these two rules, floating autosegments are associated by the AC's:



The characteristic feature of Goldsmith's approach is that transparent vowels have as their predictable value the value which is also specified lexically. The proposal then crucially rests on the assumption that back vowel roots are

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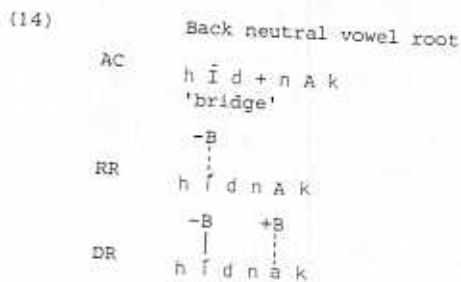
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Let us observe that within the approach to transparent vowels discussed here, these vowels are relevant to the harmony process in the sense that they can become associated to the lexical value, just like ordinary harmonizing vowels. We will say that both transparent and harmonizing vowels are *accessible* for the lexical value.¹³

We might observe that the term *transparent* is not entirely appropriate. If a neutral vowel occurs in a back vowel root each vowel gets assigned a value by a feature-filling rule (RR or DR). The neutral vowel is not by any means transparent, if this term is interpreted as meaning that neutral vowels "let through" [+B] while being themselves phonetically [-B]. This point becomes even clearer if we consider roots which only contain neutral vowels, the so-called neutral vowel roots. In Hungarian most neutral vowel roots take front suffixes, but there are about 60 roots which take back suffixes. We will refer to these categories as *front neutral vowel roots* and *back neutral vowel roots*, respectively. In terms of the above analysis, what happens when we attach a suffix to the latter category is exactly the same as what happens in the case of back vowel roots like *radfr*:



Comparing (13) and (14) we can make the generalization that after a neutral vowel which is not in the scope of, or associated to, a [-B] autosegment suffixes get the default value [+Back]. Clearly, the term *transparent* makes no sense at all in the case of neutral vowels occurring in roots like *híd*, where they are not preceded by a back vowel. In practice however we will continue to use the term *transparent*.

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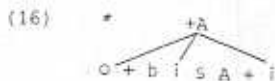
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Hence we need a condition which blocks the emergence of *discontinuous association*.¹⁵



Observe that although Pulleyblank's analysis of opaque segments conforms to the UH in not specifying default values, it does not crucially depend on the UH. One could specify both [+A] and [-A] and still maintain that opaque vowels are not prelinked. However, given the UH in this form Pulleyblank's treatment is the only one possible, since if [-A] cannot be used in the lexicon, one cannot associate it to low vowels in the lexical stratum.

1.2.5. *Combining the modifications and why this doesn't work*

Consider the following. Given the UH and a harmony system based on an arbitrary feature [F] there are two possibilities if a segment with a predictable value for F occurs in this system. Either the predictable value is the value which is specified lexically or it is identical to the default/complement value. Now if we assume that the predictable value is filled in at the end of the derivation in both cases, in the first case the result will be a transparent vowel (the Hungarian situation), whereas in the second case the result will be an *opaque* vowel (the Akan situation). In these terms the behaviour of neutral segments as either transparent or opaque will depend on the choice of the lexical value.

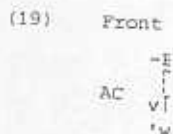
In (18) we state the correlation just mentioned in the strongest form possible:

- (18) A neutral vowel is transparent iff its value for [F] is the same as the lexical value
 A neutral vowel is *opaque* iff its value for [F] is the same as the default/complement value

The actual correlation between the behaviour of neutral segments and the nature of their (predictable) value is less straightforward, however. We will now show that it is in fact untrue that neutral segments which have the lexical value

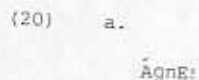
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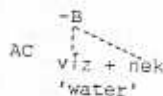
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Consider the derivations in (19):

(19) Front neutral vowel root



Most neutral vowel roots in Hungarian behave like $v\check{z}$ and take front suffixes. The type illustrated in (14) belongs to the exceptional category. Our first point is that the representation of $v\check{z}$ represents a problem. We must assume that [-B] is present in the lexical entry, although its presence is predicted by the RR (12b). This means that in certain cases the RR which assigns [-B] to a non-low unrounded vowel must apply in the lexical stratum (leading so to speak to opaque behaviour of the neutral segments in question), whereas in other cases it must apply at the end of the derivation. This gives us the difference between $v\check{z}$ and $h\check{d}$, respectively.¹⁶

The following argument leads to the same conclusion. One of the transparent vowels, viz. short /e/, when occurring after a back vowel behaves ambiguously. After roots such as $\check{A}gnes$ 'Agnes' both variants - nek and nek - are possible. This means that roots of this type have two underlying representations:

(20) a. $\check{A}gnEs$ b. $\check{A}gnes$

$$\begin{array}{c}
 \text{-B} \\
 | \\
 \check{A}gnes
 \end{array}$$

(20a) and (20b) parallel $h\check{d}$ and $v\check{z}$ respectively. The alternant in (20b) is in effect disharmonic; it takes nek. Again we see that (12b) has "applied" in the lexical stratum to generate (20b).¹⁷

The approach to transparent segments discussed in sect. 1.2.3. is successful then because RR (12b) is prevented from applying in the lexical stratum in most, but not all cases. But RR (12b) introduces the lexical value and if we were to follow Pulleyblank (1985b) in this respect, it should consistently apply in the lexical stratum. The problem with the approach inspired by Goldsmith is not only that it conflicts with the view that RR introducing the lexical value must apply in the lexical stratum, but also that a flat denial of this view is clearly wrong. As we have just seen, we can't say that RR's always apply late in the derivation and it can be shown that at least in some

cases an RR must apply in the lexical stratum wherever it can. A case in point will be encountered later on in the analysis of Turkana. We will see that glides participate in the harmonic process, acting as opaque segments. But glides are predictably [+ATR], which we will argue is the lexical value.

It seems that the best we can do if we want to stick to the treatment of transparent vowels discussed in sect. 1.2.3. is admit that RR's introducing the lexical value indeed apply early, rather than late, but that in particular cases their application is delayed, somehow or other.

The situation found in Hungarian where neutral segments which have the lexical value are either transparent or opaque, is not unique for front-back harmony. The same phenomenon is encountered in ATR-systems. Languages which have ATR-harmony do not always have two fully symmetrical sets of vowels. We have already discussed Akan, in which the low vowel region is asymmetric. In addition to nine-vowel systems, we also can find seven-vowel systems. In cases of this type the high vowel region is asymmetric as well. In Van der Hulst and Smith (in prep.) several systems of this type are discussed. See also Van der Hulst and Mous (1986). One of the inevitable conclusions is that in systems in which the high vowels are predictably [+ATR] (i.e. have the lexical value), they can act as opaque, as well as transparently. If what we assumed earlier was correct (i.e. that (18a) is a biconditional), we would expect that the high vowels always act transparently in such cases.

It is quite clear that neutral segments which behave transparently, although phonetically specified for the lexical value, behave as if they have the non-lexical value. This leads us to formulate the following paradox: Transparent segments make a harmony system phonetically opaque (because they lead to discontinuous harmonic spans). Opaque segments on the other hand make the system phonetically transparent.¹⁸

There is of course a difference between transparent vowels which are not flanked by non-neutral vowels in the root, and transparent vowels which occur alongside non-neutral vowels. If a transparent vowel occurs in a polysyllabic root with non-neutral vowels there is a synchronic "clue" for its counter-phonetic behaviour, but if it occurs on its own (or with other neutral vowels) there is no such clue. This makes Hungarian roots like *híd* (which take back vowel in suffixes) and comparable [+ATR] roots taking [-ATR] suffixes synchronically marked and presumably diachronically unstable. That transparent behaviour is more stable in polysyllabic roots is understandable. By changing to opaque behaviour one gains phonetic transparency although one acquires disharmony,

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thus endangering the harmony system. Both situations add to the complexity of the grammar.

So far we have seen that the approach adopted from Goldsmith (1985) faces two problems. Firstly, it presupposes that lexical values are supplied late. This is problematic because it goes against the "logic" of the theory, i.e. against convention (7c). Secondly, the rules which must assign the lexical value should not apply late in all cases. So, even if we grant that these rules apply early, we have no straightforward way of delaying their application so as to arrive at the transparent behaviour of neutral segments. We will now add a third problem.

As mentioned in section 0., neutral vowels do not necessarily have a predictable value for the harmonic feature. We spoke of pseudo-neutral vowels in this respect. Two cases require to be distinguished here. The first involves the irregular immutability of some occurrences of a vowel that otherwise displays normal harmonic behaviour. The second concerns the case where all occurrences of one partner in a pair of vowels standing in a harmonic relationship are immutable in this way.

To illustrate the first case, suppose that a language has /i/ ([+ATR]) and /ɨ/ ([-ATR]), and that some morpheme consists of an invariable [+ATR] /i/, such that the [ATR] specification of following vowels is conditioned by the vowel preceding the invariable /i/. Such invariable /i/'s would then always be [+ATR] and transparent. Note that we could not have a late rule assigning [+ATR] to a vowel which is [+high, -back] because this would also affect harmonic (i.e. variable) [+high, -back] vowels which have failed to come under the scope of a [+ATR] autosegment and which have to get the default value [-ATR]. We will discuss a situation of this type in section 2.2.¹⁹

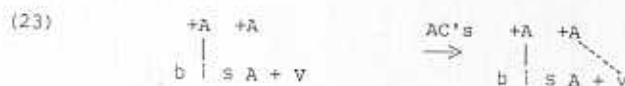
The second case arises in Khalkha Mongolian, where /i/ in a non-initial syllable is transparent for rounding harmony while a "rounded /i/", viz. /ū/ exists in the language. The two cases differ, as noted above, in that in Khalkha /i/ is always transparent, whereas in the first type of case a segments exhibits a dual behaviour - sometimes behaving as a normal harmonic vowel, and sometimes behaving as a transparent vowel.²⁰

The problem in cases where pseudo-neutral vowels are involved is then that the rule which assigns the lexical value to these segments must not only be "delayed" (cf. supra), but it must also discriminate between vowels which must undergo it (the transparent ones) and harmonizing vowels, which must get the default value. It seems that we have no choice but to mark the transparent

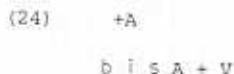
This kind of abstract account faces a problem in that it cannot in general be the case that we treat transparent segments by going through an abstract phase in the derivation. The abstract approach will only work if the harmonic counterpart of the transparent segment does not occur in the language. But this is not always the case, as we have seen above in our discussion of pseudo-neutral segments. This argument against the abstract analysis of transparent vowels was first put forward in Anderson (1980).

A second possibility of "explaining" the transparency of /a/ would be to adopt the approach suggested in sect. 1.2.3. A treatment which would be in the spirit of the Goldsmithian approach would involve the assumption that [-A] rather than [+A] was the lexical value. In that case the /a/, being [-ATR], has the lexical value, and therefore can be transparent, in accordance with the above findings. However, we will argue below in favour of using single-valued features, and such a position would exclude any analysis which makes use of markedness reversal.

On the assumption then that [+A] is the lexical value we are apparently compelled to set up an underlying representation like that in (23) to account for the transparency of /a/. As in the analysis of Akan, we would have to say that [+A] cannot associate to the low vowel. Hence in trying to associate the second [+A], we must pass over to the suffix vowel:



Must we conclude then that we can in fact analyse Akan? The answer is No. A representation like that in (23) must be considered to be illformed if we assume that the wellformedness of representations is governed by the *obligatory contour principle* (OCP), which states that identical autosegments may not be adjacent. Below we will in fact argue that a configuration like that in (23) would automatically be reduced to:



Clearly, (24) is not suitable for representing transparent /s/'s, because if we apply the AC's to this configuration the low vowel will block spreading.

Note that we now actually predict that only monosyllabic roots with a low

vowel could be followed by [+ATR] suffixes, because in that case there would be no violation of the OCP, since only one instance of [+A] would occur. This prediction is borne out. In Maasai, two such roots with /a/ occur which take [+ATR] affixes (cf. Levergood (1984)):

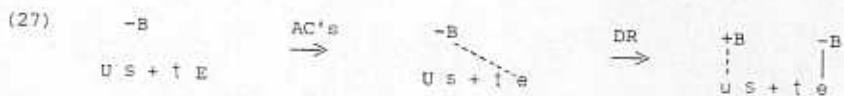


In this case an opaque vowel occurs in a root which also contains [+A]. This autosegment cannot associate to the low vowel, but it can reach the suffix vowel without violating the no skip condition.

We can test the predictions we make here with respect to a different type of harmony, i.e. front-back harmony. In Hungarian we find a situation in which an older opposition between the front vowel /i/ and the back vowel /ɔ/ has been lost in favour of the lexical value [-Back]. However, languages having front-back harmony may also show mergers in the direction of the non-lexical value. This has happened in the Turkish dialect spoken in Vidin, Bulgaria (cf. Vago (1973:582-3)), where /ɔ/ and /ü/ have gone to /o/ and /u/ respectively. If a correlation exists between merger toward the non-lexical value and opacity, it must be the case that /u/ consistently displays opaque behaviour, i.e. behaves as a back-harmonic vowel, except perhaps in the case of monosyllabic roots. Vago does report cases in which /u/ deriving from /ü/ still takes front suffixes (cf. 26a) and these are all cases of monosyllabic roots:

- (26)
- | | | | | |
|----|--------|---------|--------|---------|
| a. | us-te | 'three' | dor-te | 'four' |
| b. | buz-da | 'ice' | oq-ta | 'arrow' |

These roots could be represented analogously to the examples from Maasai:



Of similar interest is Vogul, also discussed by Vago. Again we find mergers in the direction of the default value (this time, so it seems, only for some lexical items) and again the examples where the resulting vowel behaves as if it still had the lexical value are monosyllabic roots.²³

It is obvious that the above analysis confirms our theory proposed in the previous section.

1.3. Another

1.3.1. Sing.

In the present section we discuss a language in which we assumed that the neutral vowel is [i]. There are of course other arguments in favour of this analysis.

It is striking that the neutral vowel in this language is [i]. This feature is [i] in the single-vowel system of Kaye, Lowenstam and Seuren (1980). The feature system of this language is similar to that of the other languages discussed in this paper.

The feature system of this language is similar to that of the other languages discussed in this paper. The neutral vowel is [i] in the single-vowel system of Kaye, Lowenstam and Seuren (1980). The feature system of this language is similar to that of the other languages discussed in this paper.

- (28) a. [i]

Now if we extend the analysis to the other vowels, we find that the neutral vowel is [i] on transp

It is obvious that we cannot base a solid argument on the limited information supplied by Vago, but it is encouraging that the examples he has chosen confirm our hypothesis. We have found it useful to point to an area where the theory proposed here can be tested and, perhaps falsified, but the systems mentioned must be investigated in greater depth.

1.3. Another synthesis

1.3.1. Single-valued features

In the preceding section we stated that it would be possible to explain why a language like "Akan" in which /a/'s act as transparent does not exist if we assumed that markedness reversal is not possible.²⁴ We take this as an argument in favor of a feature system in which features are single-valued. There are of course other arguments for this position, but we will not go into these here.

It is striking however that in the single-valued feature frameworks known to us the following holds: for the front-back dimension the single-valued feature is [i] (roughly: front, unrounded), and for the tongue root dimension the single-valued feature is [advanced] (cf. for example Rennison (1985), Kaye, Lowenstamm and Vergnaud (1985)). Given the correctness of single-valued feature systems which incorporate these claims, we predict exactly the array of possibilities that is attested.

The feature systems proposed in the publications mentioned can be characterized as *tridirectional* (cf. Rennison (1983)). The primitives correspond to the three points of the vowel triangle (i.e. [i] [u] and [a]), plus additional features such as [A] (for advanced tongue root) and [N] for nasality. It is interesting that given such a feature framework, the Goldsmithian approach in respect of transparent vowels in Hungarian is in fact not possible. This point was made in Ewen and Van der Hulst (1985). A characterization of the Hungarian vowels system (28b) within a tridirectional single-valued feature system takes the following form (ignoring length):²⁵

- (28) a. [i] [i, u] [u] b. /i/ /ū/ /u/
 [i, a] [i, a, u] [u, a] /e/ /ō/ /o/
 [a] /a/

Now if we extract [i] as the harmonizing feature, we lose the distinction between /e/ and /a/, and consequently we cannot formulate a rule to fill in [i] on transparent vowels. We seem to have a fourth problem here for the

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approach adopted from Goldsmith (1985). Several solutions are possible, all of which seem undesirable. (We refer to Ewen and Van der Hulst for discussion.) Below we will return to this point, since it will no longer be problematic under our proposals.

We should note that the use of single-valued features makes default rules superfluous. If there is only [A], there cannot be a default rule which assigns [-ATR]. We don't need a rule like that. The phonetic component interprets a segment without the mark [A] as a segment produced with a non-advanced tongue root articulation.

There is one problem with regard to abandoning the possibility of markedness reversal. At least two cases have been reported in the literature where vowel harmony is suggested as being based on ATR, but where the [-ATR] vowels rather than the [+ATR] vowels appear to be dominant: *Noz perce* (Hall and Hall (1981)) and *Chukchee* (Kenstowicz (1983)). In our model we have been assuming all along that the dominant value is lexical, because harmony is based on spreading and not on deletion. One must perhaps assume that these two non-African systems are not based on [ATR], but the matter clearly requires further research (cf. Anderson (1980) on these matters).

1.3.2. A new approach to neutral segments

1.3.2.1. Transparent segments

In section 1. we have examined several approaches which share the property of dealing with transparent segments in an "autosegmental fashion". The most promising approach seemed the one proposed by Goldsmith. We noticed at least four problems with this approach, however. Let us now consider another way of dealing with transparent segments, which is non-autosegmental, and which avoids these problems.

It has been proposed to deal with transparent segments in terms of *segmental specification*: transparent segments are specified with a segmental feature [-Back]. In that case we need no rule filling in [-Back]. This immediately takes care of the four problems we had with Goldsmith's proposal.

a. There is no rule filling in the lexical value at the end of the derivation. Transparent segments can be specified in the lexical stratum.

b. If some neutral segments behave opaquely rather than transparently this can be dealt with by specifying the former autosegmentally and the latter segmentally. The burden of idiosyncrasy is placed on the lexicon, which is entirely as it should be, i.e. we get rid of the "delayed application" effect.

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c. Transparent segments which do not have a predictable value can likewise be specified segmentally. Since there is no rule filling the value in we don't need a diacritic.

d. The problem noted for Hungarian also disappears. Neutrals are specified for [i] segmentally in the lexical stratum and the problem of not being able to formulate a rule filling in [i] doesn't arise.

This way of dealing with transparent segments goes back to Hart (1981) and is furthermore to be found in Van der Hulst and Smith (1982), Booij (1984), Ewen and Van der Hulst (1985), Hermans (1985) and Vago (forthc.).

We would now like to claim that the segmental solution is hard to reconcile with the autosegmental approach. In current versions of this model it simply doesn't make sense to speak of segmental specifications, since there is no "segmental core". All features occupy autonomous tiers which are linked to the skeletal tier. We will therefore propose an alternative treatment of transparent segments, which is purely autosegmental in spirit.

Let us start out by adopting Pulleyblank's idea that transparent segments which have the lexical value are associated to this value in the lexical stratum as follows:

(29) [i]
|
v

Segments of this type will be called *inherently specified*. A crucial property of neutral segments is that they don't spread. Suppose then that we adopt an idea first advanced in Halle and Vergnaud (1981, 1982), namely that the AC's do not apply to autosegments which are already associated. If we adopt this view there is no reason why we couldn't represent neutral vowels as underlyingly linked:

(30) [i]
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r A d i r + n A k

The two vowels straddling the transparent vowel will phonetically be interpreted as back and the correct surface form will be derived. We now have to explain why neutral vowels in suffixes "let through" the [-B] value if they are preceded by a floating instance of [i]. This situation arise in the

following example (cf. fn. 7):

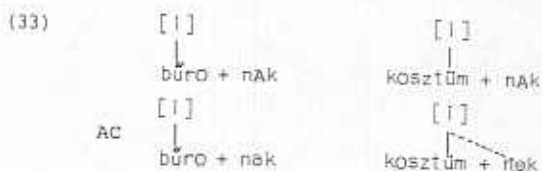


Here we invoke the OCP. The configuration given in (31) is automatically converted into that in (32):



We must observe that this proposal presupposes that the AC's can distinguish between derived and underlying association lines. So far we have assumed that the AC's apply cyclically. If we associate an autosegment to vowels in cycle n , how are we to know whether the AC's can apply again in cycle $n+1$? The problem is of course that in cycle $n+1$ there is no longer a floating autosegment. However we do not have to say that the AC's are sensitive to a difference between derived and non-derived association lines. The whole problem doesn't arise if spreading applies non-cyclically.

The reader will now want to know how we are going to deal with disharmonic roots. Disharmonic roots are presented as follows (cf. 10):



As shown the $[i]$ of the second example must spread to the suffix. Yet we have represented it as underlyingly linked. The inevitable conclusion is that if we use lexical association lines for transparent vowels, we can't also use the same mechanism for opaque vowels.

The solution to this problem directly leads us to the issue of how we are going to represent opaque segments.

1.3.2.2. Opaque segments

To solve the problem of representing disharmonic roots we would somehow like to say that the $[i]$ autosegment is floating, but includes only one of the root

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Since the [i] of *kosɔtɔm* must spread to the suffix vowel we will assume that segmental boundaries (or prosodic boundaries in general) create a "one-way" opacity: you cannot go in, but you can go out. Observe that this account of disharmonic roots makes an appeal to the SCC superfluous.²⁶

The mechanism of segmental binding then gives us a complete formal account of opacity. We can also use it to deal with the opaqueness of low vowels in Akan. To do this we will adopt the convention that if a particular segment cannot become associated to the harmonizing feature, it will automatically be opaque in the sense just proposed. Hence:

$$(37) \quad \begin{array}{c} * [F] \\ | \\ V \\ | \\ [...] \end{array} \rightarrow [F] \text{ -- } \left(\begin{array}{c} - \\ V \end{array} \right) \text{ --}$$

In cases of this type opacity is predictable on phonological grounds, which is not the case in disharmonic roots where the opacity is an idiosyncratic property of particular morphemes.

According to (37) the representation of the following Akan form is represented as in (38):

$$(38) \quad \begin{array}{c} A \\ \left(\begin{array}{c} A \\ A \end{array} \right) r I + I \end{array} \xrightarrow{\text{AC's}} \begin{array}{c} A \\ O + k A r \left(\begin{array}{c} + \\ + \end{array} \right) \end{array}$$

The form in (38) illustrates that we must deal with opacity in this way. Suppose we assume the correctness of Pulleyblank's treatment and also that the AC's apply non-cyclically. Obviously we would get the wrong result if the AC's apply by associating [A] to the leftmost vowel which is in its scope:

$$(39) \quad \begin{array}{c} A \\ O + k A r I + I \end{array} \rightarrow \begin{array}{c} A \\ | \\ O + k A r I + I \end{array}$$

Given the representation in (38) [A] cannot associate to the prefix vowel. This result points we believe to the consistency of our proposals.

Our account of opacity has a slightly disadvantageous consequence however. It prevents us from utilizing the OCP to rule out such structures like that given in (23), as in the terms of the present account a representation like

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that in (40) is available:

$$(40) \quad \begin{array}{c} A \\ \left(\begin{array}{c} \\ \\ \end{array} \right) A \\ b \text{ I s } \left(\begin{array}{c} \\ \\ A \end{array} \right) + V \end{array}$$

This would mean that we would be capable of analysing Akan' after all. If the OCP cannot be held responsible for preventing neutral vowels which have the non-lexical value from acting as if they were transparent, we might say that it is the relative markedness of floating features which always surface on other morphemes than the morpheme which induces them, which explains the rare occurrence or non-occurrence of transparent /a/'s. In addition to this, or perhaps rather, instead of this, we will assume that there is a general principle operating in harmony systems that no more than a single floating autosegment per morpheme per tier is allowed.²⁷

If this last principle is applicable it would still explain why morphemes with one floating autosegment which cannot be associated with the inducing morpheme are possible. Cf. the cases discussed in (25) and (27). They would be represented as follows:

$$(41) \quad \begin{array}{cc} \text{a.} & \begin{array}{c} \left(\begin{array}{c} \\ \\ A \end{array} \right) \\ C \left(\begin{array}{c} \\ \\ A \end{array} \right) C + V \end{array} & \text{b.} & \begin{array}{c} \left(\begin{array}{c} \\ \\ [i] \end{array} \right) \\ C \left(\begin{array}{c} \\ \\ U \end{array} \right) C + V \end{array} \end{array}$$

It is striking that Levergood presents evidence showing that a representation such as that in (41a) is in fact necessary, whereas the one given in (25) leads to incorrect results, since it predicts that under suitable circumstances the [(+)A] would dock onto a prefix vowel, which it in fact never does. Levergood therefore concludes that /a/'s must be specified as [-A] in order to reach a representation like that in (42). The configuration in (41) has of course the same effect:

$$(42) \quad \begin{array}{c} -A \quad +A \\ | \quad \diagdown \\ C \text{ a } C + V \end{array}$$

We will conclude this section by investigating an unexpected (but as it turns out desired) result. By differentiating between an autosegment being associated to a skeletal point and being bound to a skeletal point, we have created 6 possible situations:

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Interestingly, we know of two cases, which exactly match this so far imaginary situation. The first case is Khalkha Mongolian. According to Chinchor (1979) a [+R] autosegment ([u] in our system) does not spread across high rounded vowels. However, following these rounded vowels only unrounded segments occur. What prevents the OCP from applying? We suggest that the two occurrences of [u] are separated by segmental boundaries, i.e. the second [u] is not only associated to a skeletal point (which prevents it from spreading) but also bound to a segmental domain.

The second case involves nasal spreading, in Applecross Gaelic (cf. Van der Hulst and Smith (1982)). Here nasal consonants block the spreading of [N] and as in the previous case they don't spread themselves. Again we must prevent the OCP from applying.

The two cases involve the following representations:

$$(45) \quad \text{a. } [u] \left(\begin{array}{c} [u] \\ | \\ X \end{array} \right) \dots \quad \text{b. } [N] \left(\begin{array}{c} [N] \\ | \\ X \end{array} \right) \dots$$

which is exactly what we have in (44).²⁸

The occurrence of blockers which do not spread was denied in Clements & Sezer (1982). The examples discussed here suggests that this is too strong a claim. More important however is the fact that the occurrence of such elements is correctly predicted by our model.

1.4. Concluding remarks

Let us summarize the proposals we made above. We have classified vowels in two groups: *accessible* and *inaccessible* vowels. Inaccessible vowels are opaque and are formally represented as segments whose segmental boundaries extend to the harmonic tier. Accessible vowels fall apart in two categories. There are those which are underlyingly associated (these are the so called transparent vowels) and those which are not associated (the harmonizing vowels). The projection of segmental boundaries as well as the presence of underlying association lines is either predictable by rule or idiosyncratic,

We have furthermore shown that the AC's only apply to floating autosegments and do not have to apply cyclically. To explain why neutral segments which do not have the lexical value behave exclusively as opaque we have adopted a single-valued feature system and a principle requiring that at most one floating

autosegment occurs per morpheme.

Finally we showed that our theory predicts the existence of opaque segments which do not set off a harmony span themselves, which do in fact happen to occur.

2. Vowel harmony in Turkana and Bari

In this section we will provide a (partial) autosegmental analysis of vowel harmony in Turkana and Bari. The Nilotic languages in general appear to be a fruitful testing ground for theories of vowel harmony and interesting autosegmental analyses have been provided in Levergood (1984), Steinberger & Vago (to appear) and Vago & Leder (to appear). The last two mentioned publications deal with Bari and Turkana, respectively. The authors argue that both systems present serious problems for what they call a "lexical phonology analysis", while a straightforward analysis is available within the theory of multileveled autosegmental phonology, as developed in Vago (in prep.). Our purpose here is to show that these "serious problems" can be dealt with in what we believe to be the more restricted model which we proposed in the previous section. We will not however attempt to offer a critical discussion of Vago's multileveled theory here.

2.1. Turkana vowel harmony

2.1.1. The basic data

The data that we consider are the same as those that form the basis of Vago and Leder's analysis (henceforth VL). They derive from Dimmendaal (1983) and additional (as yet unpublished) notes which Dimmendaal has kindly made available to both VL and us. We will attribute much weight to Dimmendaal's factual addenda, which VL have mentioned only in footnote additions.

Turkana has nine vowels:²⁹

- (46) [+ATR]: i u e o
 [-ATR]: ɪ ʊ ɛ ɔ a

Roots can be classified as being [+ATR] or [-ATR], and in many cases affixes harmonize to the stem:

On Neutral Vow

- (47) a. do|
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 b. go|
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 c. se|
 |por

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- (48) imo|

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- (49) Lexical
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(47)	a.	doi	'arrive'	a + doi + uni	'arrive here'
		lom	'enter'	a + lom + oni	'enter here'
	b.	gogon	'strong'	e + gogon	'he is strong'
		dit	'small'	e + dit	'he is small'
	c.	sebey	'Sebey'	ə + sebey + it	'Sebey person'
		poran	'Boran'	ə + poran + it	'Boran person'

At first sight then we might wish to say that Turkana has a system involving root control - in other words that the value of the feature [ATR] for the whole word is determined by the value of [ATR] holding for the root. We encounter cases however where suffixes appear to determine the harmonic value of the root rather than the other way around, as in (48):

(48)	imoj	'eat'	ak-is-imoj	infinitive-cause-EAT
			a-imoj-i	ips-EAT-aspect
			ak-imuj-eeeni	infinitive-EAT-habitual

The first two words show that the root is [-ATR]. In the third case however, in the presence of the [+ATR] suffix /eeeni/ the root shows up as [+ATR]. Hence the Turkana harmony system is *dominant*.³⁰

There are no prefixes which act as dominant and it is therefore the case that Turkana stands halfway between root control and dominant systems: it allows the lexical value in both roots and suffixes. We arrive at a three-way distinction:

(49)	Lexical (i.e. dominant) value only in roots: Akan, Hungarian
	Lexical value in roots and suffixes: Turkana
	Lexical value in any morpheme: Tunen ³¹

The existence of this three-way distinction and the fact that Turkana has properties of both root-control (toward prefixes) and dominant systems shows that the typological distinction between root control and dominant systems is not a very principled or "deep" one.³²

In the next three sections we will discuss various complications involving the opaqueness of /a/, glides, and specific suffixes.

2.1.2. The low vowel /a/

As can be seen in (46) there is no [+ATR] counterpart of /a/. This means that /a/ is *neutral* in respect of [ATR] harmony. In other words it does not undergo a parallel variation to the other vowels of Turkana (although, as we will

same point with reference to the structure in (39).) The autosegment, also part of the root is located to the right of the low vowel. The autosegmental representation of (53) is then:

$$(54) \quad E + k \begin{pmatrix} [A] \\ (A) \end{pmatrix} | EES \xrightarrow{AC's} E + kA \overset{[A]}{\wedge} ees \xrightarrow{PI^{34}} [ekAees]$$

The following example illustrates the opaque behaviour of /a/ when occurring in a suffix:

(55) a. $\eta\iota + k\iota\eta\iota m + a\eta\eta + o\tau + \iota n$ [ɨkɨkɨmɨɨoɨɨn]
 masculine-DEAF-habitual-deverbative-plural

b. $\eta\iota + k\iota\eta\iota m + \begin{pmatrix} [A] \\ (AA) \end{pmatrix} n + o\tau + \iota n \xrightarrow{AC's} \eta\iota + k\iota\eta\iota m + a\eta\eta + o\tau + \overset{[A]}{\wedge} \iota n$

The dominant suffix /oɨ/ influences the following suffix, but not the stem because of the intervening low vowel. The opacity of /a/ is captured by the following rule (cf. 37):

$$(56) \quad * \begin{pmatrix} [A] \\ | \\ v \\ | \\ [a] \end{pmatrix} \rightarrow \begin{pmatrix} [A] - (-) - \\ | \\ v \\ | \\ [a] \end{pmatrix}$$

i.e. the segmental domain of the low vowel is projected onto the [ATR] tier.

We have seen above that structures in which a low vowel is preceded by [+ATR] vowels are ruled out by (51). Such combinations may arise from the concatenation of morphemes:

$$(57) \quad \begin{pmatrix} () \\ (A) \end{pmatrix} + \text{DUK} + \begin{pmatrix} () \\ (A) \end{pmatrix} \text{PI} \xrightarrow{AC's} a + \overset{[A]}{\wedge} b\text{UK} + o\tau\iota$$

'inf.-POUR OUT-itive'

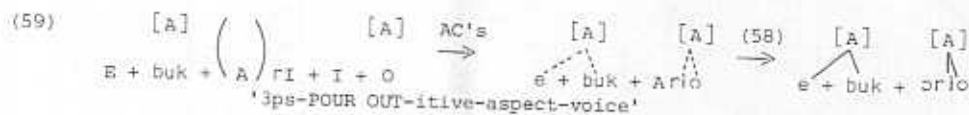
The suffixal /a/ is in such cases replaced by /ɔ/, which Dimmendaal describes as the [-ATR] mid back vowel. Originally the [+ATR] specification spread to the suffix giving a raised non-rounded vowel, which was acoustically fairly close to, but not identical to the [-ATR] counterpart of /o/ (as in present-

day Kalenjin; cf. Rottland & Otaala (1981)). As things are now the change from /a/ to /ɔ/, can no longer be interpreted as a direct result of [A] spreading, since the final vowel in (57) is not affected by this feature. We will therefore assume that the rule changing /a/ to /ɔ/ is applied after spreading:

(58) A-ROUNDING



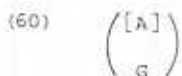
The following form illustrates application of both spreading and A-Rounding in a somewhat more complicated example:



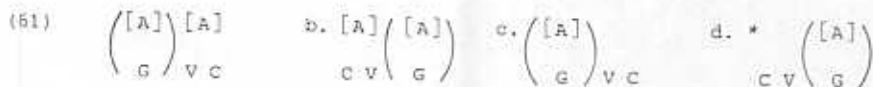
Apart then from the gap in the distribution of /a/ and its rounding after a [+ATR] vowel, the low vowel behaves like the low vowel in Akan.

2.1.3. Glides

As Dimmendaal shows, glides interfere with vowel harmony. Non-low vowels to their left must be [+ATR]. Glides are described as being [+ATR] themselves. The [A] value can be assigned by a RR, which applies in the lexical stratum. If a glide occurs in a [-ATR] morpheme this leads to a situation of disharmony: a following vowel may be [-ATR]. Hence glides must cooccur with [A] being bound to their segmental domain. Since [A] must spread it is not lexically associated:



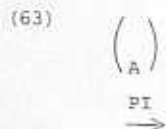
Like low vowels, glides show a gap in their distribution. They do not occur in [-ATR] roots in post-vocalic position; hence (61d) is illformed:³⁵



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(61d) then must be excluded by a constraint:

(62) * ... V G ... if the morpheme is not [+ATR]

Glides which are created in the course of the derivation from [-ATR] high vowels acquire [+ATR] value leading to subsequent spreading:

(63)
$$\begin{matrix} \left(\begin{matrix} \\ A \end{matrix} \right) + \text{kookI} + \left(\begin{matrix} \\ AA \end{matrix} \right) + \text{Ut} \xrightarrow{\text{AC's}} \left(\begin{matrix} \\ A \end{matrix} \right) + \text{kook} \begin{matrix} \nearrow [A] \\ \searrow y \end{matrix} + \left(\begin{matrix} \\ AA \end{matrix} \right) + \text{Ut} \rightarrow \\ \text{PI} \\ \rightarrow \\ \left[\text{akookyaanot} \right] \\ \text{'inf.-STOMACH-habitual-abstract' 'loneliness'}$$

In this example [A] can't spread to the right because of the low vowel.

Glides then act consistently as opaque. As they have the lexical value, this supports the correctness of the viewpoint adopted in the previous section, viz. that RR's introducing the lexical value apply in the lexical stratum.

2.1.4. Pseudo-neutrality: the opaque case

In addition to dominant [+ATR] a suffixes, Turkana appears to have suffixes which are dominant and [-ATR]. In Dimmendaal (1982c) it is said that the presence of such a dominant suffix causes vowels which are [+ATR] occurring to its left to become [-ATR]. If this situation would obtain then it would be hard to maintain that [-ATR] is not specified lexically. However Dimmendaal (p.c.) informs us that the facts are somewhat different. The difference appears to be crucial.

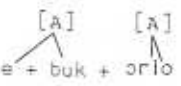
The morpheme /Et/ has an invariable [-ATR] vowel. The influence it may have on its preceding environment is optional and local, as the form in (64b) shows. If this suffix follows a series of [+ATR] vowels, only the vowel to its immediate left may optionally become [-ATR]:

(64) a. ak ido un Et ~ b. ak ido on Et
'infinitive-GIVE birth-ventive-locative-nominalizer'

The behaviour of /Et/ is apparently different from that of the truly dominant [+ATR] suffixes, which have a undisputable non-local influence. How do we account for the behaviour of invariant [-ATR] suffixes? The basic problem is not to explain why these suffixes have an optional local effect (we will deal with the local influence in terms of a post-lexical rule: cf. below), but

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What we appear to have here is a case of idiosyncratic opacity. We must prevent [+ATR] from spreading to the vowel of /Et/ and we can do this by representing the vowel as inaccessible:

$$(65) \quad [A] \text{ --- } \left(\begin{array}{c} - \\ E \\ t \end{array} \right) \text{ ---}$$

The local influence which /Et/ may have on the preceding context involves spreading of [-ATR]. Since [-ATR] is only a phonetic feature and not a phonological feature (cf. fn.25), the rule in question must be phonetic and post-lexical. It is not entirely clear what the format for writing phonetic rules is, but for the sake of exposition we will adopt the following formulation:

(66) Regressive Harmony



A similar effect to suffixes like /Et/ is also caused by underlying /A/ appearing as [ɔ] (cf. 57):

(67) a-buk-ɔrɪ - a-bək-ɔrɪ

In this type of situation we have the same sequence of a [+ATR] vowel followed by a [-ATR] vowel, so it doesn't come as a surprise that the rule in (66) applies both here and in the case of opaque suffixes like /Et/.³⁶

The vowel of the invariable [-ATR] morphemes behave exactly like the surface [ɔ]'s derived from the low vowel, but although they behave as opaque they do not have a predictable harmonic value. In other words we have here pseudo-neutral vowels which act as opaque. The identification of the pseudo-neutral vowels cannot be made on phonological grounds. It must be made on an item-to-item basis. In this case then the opacity is not predictable by rule, as in the case of low vowels, but must be directly encoded in the lexical representation of the relevant morphemes. Our theory allows us to that without needing recourse to diacritic features and in this sense we stay in line with Clement's original claim that the autosegmental model offers a straightforward way of dealing with

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idiosyncratic aspects of harmony systems (cf. Clements (1976)).

2.1.5. Reharmony

A final complication that we will discuss involves a process of reharmony, whereby [+ATR] mid vowels in the root cause opaque [-ATR] vowels to their right to become [+ATR]. Cases where this change occurs involve either the low vowel (changed to [ɔ]) or [-ATR] opaque suffixes like /rE/. This process leads to alternations of the following sort:

- (68) apedorɪ - apedorɪ
awonere - awonere

Only mid vowels trigger the rule (cf. 67):

- (69) abukorɪ - *abukorɪ

The mid vowel must form part of the root, e.g. there is no alternation of the following sort:

- (70) abunere - *abunere

In this last example we do find the form [abunere] as a result of rule (66). We might formulate the reharmony rule as follows:

- (71)
$$\begin{array}{ccc} +A & & -A \\ | & \text{---} & | \\ V & & V \\ [+mid] & & \end{array}$$

We have formulated this rule as a post-lexical phonetic rule, because it operates optionally. It is clear why in [awonere] the rule takes precedence over rule (66), preventing the occurrence of a form like [awonere]. Reharmony is more specific than Regressive Harmony.

2.2. Bari vowel harmony

In the previous section we saw a case of idiosyncratic opacity. Our sense for symmetry makes us search for "idiosyncratic neutrality". In Steinberger & Vago (1985), henceforth SV, the vowel harmony system of Bari (Eastern Nilotic) is analysed. This system is based on [ATR] and involves two sets of five vowels.

The low vowel /a/ does not alternate in all environments. In prefixes it is invariably [-ATR] and acts as opaque. We could express this regularity by formulating the following morphologically conditioned constraint, stating that the low vowel is opaque iff it occurs in a prefix:

$$(72) \begin{array}{c} [A]--- \\ | \\ v \\ | \\ [a] \end{array} \rightarrow \begin{array}{c} --(-)-- \\ | \\ v \end{array} \quad \text{in prefixes}$$

In addition some roots show a non-alternating low vowel. Such cases pose no problem, since roots of this type are simply disharmonic.

The authors then discuss a particularly interesting feature of this system, which involves data of the following type (the first set of examples is taken from Hall and Yokwe (1978), the second set from SV):

(73)	a. wer	'go'	wera-ji-ne?	'be gone'
	b. kam	'paddle'	kama-ji-ne?	'be paddled away'
	c. ring	'reproach'	ring-un-dya	'take away by force'
	d. dir	'carry between two'	dir-un-dya	'carry this way'

In each of the two cases we notice the following. The second suffix added alternates in accordance with the harmony requirement. If the root is [+ATR] we get the [+ATR] form: [ne?] and [dya], if the root is [-ATR] we get the [-ATR] form: [ne?] and [dya]. What is peculiar about the forms in (73) is that in between the root and the second suffix we find an invariable suffix which is always [+ATR]. Apparently these suffixes act as transparent. Since they are [+ATR] our model forces us to assume that [+ATR] is the lexical value, a result which is completely in accordance with the fact that Bari has the same type of harmony that we found in Turkana.³⁷

All suffixes which act like /j/ have a high vowel, but not all suffixes with a high vowel act as transparent. Hall and Yokwe speak of a "considerable number" which act transparently.

SV state the following: "Lexical phonology faces a particular problem in the Bari Vowel harmony system: neutral vowels have the same ATR value as the dominant suffixes. Thus, if the +ATR autosegment of neutral vowels is specified, then there is nothing to prevent it from spreading. [...] Recall that the invariant +ATR value of neutral vowels must be specified underlyingly:

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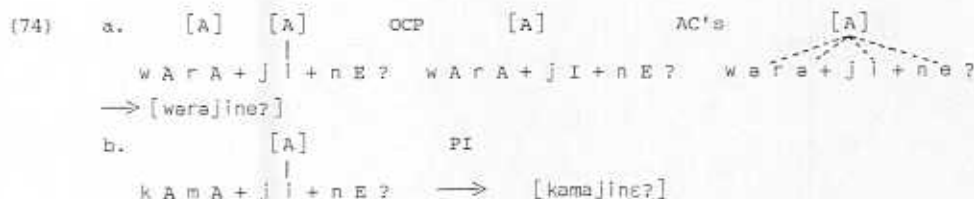
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it is not possible to predict it by general rules. In sum, we see no obvious and reasonable solution to the problem that neutral vowels pose for current versions of autosegmental theory." The treatment that then is proposed within the multileveled model is to specify neutral segments segmentally as [+ATR]. The morpheme-level feature can simply spread across segments which are segmentally specified.

The problem which SV note is not specific to the case at hand. We have argued in section 1 that transparent vowels in general are problematic for standard versions of the autosegmental model. The difference between transparent vowels in Bari and transparent vowels in Hungarian is that in the latter case the class of transparent segments could be identified on purely phonological grounds, whereas in Bari the identification is essentially morpheme-based. It now becomes clear that the high vowel transparent suffixes form the logical counterpart of the opaque suffixes in Turkana. In both cases we are dealing with what we have called *pseudo-neutral* vowels. In the case of Turkana these vowels must behave opaquely, because they have the default value. In the case of Bari they may act neutrally because they have the lexical value.

The treatment of the neutral suffixes in Bari should pose no problem then for the theory which we have argued for in section 1. Being neutral the vowel of the suffix /ji/ will be represented as being lexically associated to [A]. The two relevant derivations, corresponding to (73a) and (73b) run as follows:³⁸



The form in (74a) is subject to the OCP, which leads to the transparent effect of the suffixial /i/. In (74b) nothing happens at all. The underlying form forms the direct input for the phonetic interpretation.

To stress the point more clearly that the neutral suffixes fill an empty slot in the system we bring together the four cases:

(75)	Opacity	Neutrality
Phonological	Akan, Turkana [+low] vowel	Hungarian [-round, -low] vowels

	Opacity	Neutrality
Idiosyncratic	Turkana	Bari
	[+low] vowel	[+ATR] suffixes
	Bari	
	[+low] prefix vowel	

We are aware of the fact that much more can and should be said about the harmony system of Bari. Here we had only a modest goal and we merely wanted to point out that the neutral [+ATR] suffixes do not require a multileveled representation of one and the same feature.

It is striking that rather than being problematic for our approach, the Bari neutral suffixes fill a hole in the array of possibilities predicted by our theory.

3. Conclusion

In this article we have discussed the treatment of neutral segments within an autosegmental framework. We have proposed a typology of such elements, distinguishing between neutral segments for which the harmonic value is predictable, and those for which it is not predictable (pseudo-neutral segments). We established and explained a correlation between the particular behaviour of neutral segments and their harmonic value and proposed a "purely autosegmental" treatment of transparency and opaqueness. We showed that a number of correct predictions could be derived from the model, such as the occurrence of opaque segments which do not spread. We then proceeded to provide an analysis of two vowel harmony systems which display among other things pseudo-neutrality, and showed that the model proposed can handle such cases without using "segmental" specification, diacritic features or the like.

Notes

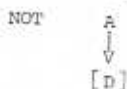
- * Earlier versions of this paper were presented during a Phonology-workshop in Tromsø and a seminar held at the dept. of African Linguistics at Leiden (sept. 1985). We thank Tom Cook, Gerrit Dimmendaal, John Goldsmith, Jonathan Kaye, Paul Kiparsky and Doug Pulleyblank for offering useful comments and criticism on those and/or other occasions.
1. In the recent autosegmental literature the term *neutral* is often used where we will use *transparent*. For a recent introduction to the general framework assumed here see Van der Hulst and Smith (1985).

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2. For a recent discussion of both segmental and autosegmental approaches to Hungarian vowel harmony we refer to Van der Hulst (1985).
3. The short /e/ typically vacillates between transparent and opaque behaviour. We will return to this point below.
4. This is possibly due to a segment structure rule which applies before the AC's, although Clements doesn't state this explicitly. In any case the predictability of [-B] on non-low unrounded vowels must be captured in a redundancy rule.
5. The AC's assumed here are those proposed in for example Clements and Sezer (1982). AC's apply from left-to-right to floating and associated autosegments alike, but association of a floating autosegment has preference over association of a non-floating autosegment. In cases of ambiguity rightward spreading takes precedence.
6. In this article capitals represent phonological segments not (yet) associated to an autosegment. Once association has taken place we use lower case letters corresponding to the surface form. We leave out the skeletal tier in most cases for the sake of simplicity and pretend that all but the harmonic features are bundled on one tier.
7. Roots which only contain neutral vowels are called *neutral vowel roots*. Below we will discuss the behaviour of neutral vowel roots of which there will appear to be two types, those which take front suffixes (the regular ones) and those which take back suffixes. There is a word formation rule which creates neutral vowelroots. From a proper name like Tibor a hypocoristic form Tib- can be derived by truncating -or. The resulting root Tib behaves like a regular neutral vowel root in that it takes front suffixes, eg. in Tibinek. Cf. Kiera → Klarinak.
8. We assume here familiarity with the theory of Lexical Phonology, in which the notion *stratum* has a well defined meaning. Cf. Kiparsky (1982) and Mohanan (1982).
9. In the derivation of búfónék we must also prevent [-B] from spreading to the suffix vowel. The problem we address here first has logical priority for if [-B] cannot spread to the second root vowel it follows from a "no skip" condition, which we will discuss below in sect. 1.2.4. (cf. 17) that it cannot go to the suffix vowel.
10. Within the approach that we propose in sect. 1.3.2. it will in fact not be necessary to invoke the SCC to prevent spreading in the case of disharmonic roots.
11. Goldsmith does not make use of the binary valued feature [+/-Back], as we do here, but uses a single-valued feature which indicates frontness; We will come back to the use of single-valued features in sect. 1.3.1.
12. Briefly, the Elsewhere Condition requires that if two rules can apply to a configuration, the more specific rule will take precedence.
13. This approach to transparent vowels shares some properties with the approach adopted in Van der Hulst (1985). In the analysis proposed there both [+Back] and [-Back] are represented in the lexicon. Van der Hulst therefore assumes that neutral vowels are "skipped" when, in back vowel roots, [+B] is associated to vowels. Given Goldsmith's approach it is no longer necessary to assume that vowels can be skipped, which, as we will see in the next section, is a welcome result. Observe that we must assume that the AC's do not reapply after the DR has applied.

14. The prime motivation for this move comes from the study of tonal phenomena and in particular from the behaviour of so-called depressor consonants. We refer to Pulleyblank's paper for further details.
15. Cf. fn. 13; it will be clear that Pulleyblank's treatment of opaque segments would be incompatible with an approach to transparent segments which required that such segments be skipped.
16. (12b) predicts a bound autosegment, rather than a floating one, but it wouldn't make any difference if we were to say that [-B] was linked to the neutral vowel; it would still spread to the suffix-vowels. We couldn't say that [-B] is introduced by (12b), followed by an application of the AC's, because this would be inconsistent with the derivations in (13) and (14) which presuppose that the AC's do not apply after (12b). Cf. fn. 13.
17. If vowels which predictably have the lexical value can behave transparently or opaquely, one predicts that there could exist a language having a harmony system like that of Hungarian, but different in that its neutral vowels behave consistently as opaque. Kiparsky (p.c.) tentatively suggests that Ostyak, a closely related Ugric language, might be a case in point. Without further investigation, we cannot be sure that Ostyak is a system of this type, but for the sake of the argument we will assume that systems of this type do in fact occur.
18. Is there a principled difference between the Hungarian case and what we find in reduced [ATR]-systems? The presence of transparent vowels seems much more impressive in the former case. We believe that this difference can be attributed to a difference in morpheme structure. The impression of vowels acting transparently results from their occurrence in polysyllabic roots. When we observe that polysyllabic roots are less typical of West African languages than they are of Hungarian, we can understand why transparent vowels are more typically found in the latter type. In Van der Hulst and Mous (1986) it is shown that Tunen has roots with transparent vowels which are parallel in every relevant respect to what we find in for example Hungarian.
19. Cf. also Van der Hulst and Mous (1986). In Tunen some /o/'s alternate with /ɔ/, whereas others are invariably [+ATR] and transparent. This type of situation also arises in Finnish where in some words /ū/ and /ō/ behave transparently, whereas their harmonic counterparts /u/ and /o/ exist in the language (Cf. Campbell (1980)).
20. The transparency of /i/ with respect to rounding harmony is in itself problematic for the theory outlined in sect. 1.2.3. Since, presumably, [R] is the lexical value, /i/ has the non-lexical value and cannot be transparent. Cf. Chinchor (1979) for an autosegmental analysis.
21. In itself the diacritic approach is not illogical. After all, vowels which behave as transparent without having a predictable value cannot be identified on phonological grounds. What we have here is *idiosyncratic transparency*. In the analysis of Turkana in sect. 2.1. we will encounter *idiosyncratic opaqueness*, i.e. particular vowels which do not have a predictable value will behave opaquely in certain suffixes. They too could be handled with a diacritic:



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This constraint tells us that vowels marked as [D] cannot become associated to [+ATR].

22. The derivation in (22) involve the application of a neutralization rule:

$$\begin{array}{ccc} & & -A \\ & & \downarrow \\ v & \rightarrow & v \\ [+low] & & \end{array}$$

The derivation parallels the one given in (1b-d).

23. Potentially problematic is a third case reported by Vago. In Forest Chereemis we find both front-back and rounding harmony. The low vowel /a/ does not induce rounding. However in a few cases we find /a/ occurring in the final syllable of a polysyllabic root followed by the rounded suffix allomorph. In each case the vowels preceding /a/ are round.
24. A related problem is that the Ostyak case mentioned in footnote 17 can be described in two ways. Recall that the harmony system of this language might be such that the vowels acting as transparent in Hungarian here act as opaque. Above we assumed that the difference between Ostyak and Hungarian would be that in Ostyak the neutral vowels would be associated to the autosegment [-Back] in the lexical stratum whereas in Hungarian this would not be the case. But the difference might just as well be accounted for by assuming that in Ostyak [+Back] is the lexical value, rather than [-Back]. In that case the non-low unrounded vowels of Ostyak must count as opaque in accordance with the theory presented, because they cannot be associated to the lexical value, which is [+Back]. We would exclude the possibility of analysing Ostyak in two different ways if we abandon the idea that features are binary valued, since we then exclude the possibility of having "reversed markedness".
25. Compositions of primitive features leads to a "compromise", i.e. [i] + [a] gives a mid vowel /e/.
26. One might argue that it would be sufficient to project only the boundaries of either back or front vowels to handle disharmonic roots. Nothing is gained by this. The choice would be arbitrary and we would need the SCC after all.
27. One might wonder whether it is possible for a [-ATR] root to take both [+ATR] suffixes and prefixes. A case in point may be present in Datooga (S. Nilotic). Rottland (1983) reports that the vowel /e/ behaves ambiguously. Some roots with /e/ take [-ATR] prefixes, while others take [+ATR] prefixes. In the second case the /e/ presumably goes back to */e/. We haven't found a relevant example in which both a prefix and a suffix are "determined" by /e/'s of the second type. If it turns out that such examples do exist, we are forced to conclude that representations as the following are necessary:
- (i)
$$\begin{array}{ccc} & A & A \\ & \left(\begin{array}{c} v \\ c \end{array} \right) & \\ v + c & & c + v \end{array}$$
- i.e. with two floating autosegments. We note that treatments within competing models require a similar complex representation. Within Pulleyblank's approach one would be forced to say that certain /E/'s (let us identify them with a diacritic [D]) cannot be associated to [+ATR]. Roots containing an /E/ of this type must then be represented as in (ii):

(ii) +A +A
 V + CeC + V
 [D]

It will be clear that if V may not associate to [+A] one instance of [+A] will be insufficient. In terms of a more standard account of opacity the following representation is required:

(iii) +A -A +A
 V + CeC + v

Observe that there is nothing wrong with taking both disharmonic prefixes and suffixes. In Okpe this happens when [+ATR] roots take [-ATR] affixes. But in this case we have a mirror-image situation. The representation of the relevant Okpe roots is simply

(iv) A
 V + CeC + v

There is no spreading of [A] and affix vowels get the default value.

28. Another example where we find the type f. situation is discussed in Van der Hulst and Mous (1986).
29. In this section, expressions like "[+ATR]" and "[-ATR]" no longer refer to phonological features, which are, as proposed, single-valued. Rather they refer to the actual phonetic quality of the vowels in question.
30. The distinction root control vs. dominant is discussed in Vago (1980). Aoki (1968) uses the terms symmetrical vs. asymmetrical.
31. We refer to Mous (1986) and Van der Hulst and Mous (1986) for an analysis of vowel harmony in Tunen.
32. We can think of one reason for invoking "root-control" as a primitive notion. In a language having palatal (or rounding) harmony a back (or non-round vowel root may be followed by a non-alternating suffix which is itself front (or round). Suffixes following this invariable suffix will have a front (or round) variant, but roots will not become front (or round). Since the auto-segment of the invariable suffix spreads (i.e. is not transparent) it must not be associated. The question is then how we will prevent it from spreading to the root, unless we stipulate that in systems of this type suffixes cannot influence roots.
33. Recall that [A], [u] and [a] represent single-valued features.
34. "PI" means phonetic interpretation. In subsequent examples the effect of PI is encoded in the output of the AC's unless indicated otherwise.
35. In roots of type c, [A] must not spread to the following vowel. Either we say that post-glide vowels are opaque or we appeal to the SCC. Another analysis of glides would be to introduce them as $\underset{C}{A}$ and attribute leftward spreading to a rule rather than to the AC's. Rightward spreading of glides does not occur due to independent reasons such as the non-occurrence of (61a) and the fact that in (61c) [A] doesn't spread rightward.
36. The effect encoded in rule (66) is also discussed in Rottland & Otaala, who discuss the influence of the low vowel alternant [ɔ]. They only mention regressive assimilation affecting mid root vowels and they also add that

On Neutral V

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[-ATR] spreads further to the left if the root contains more vowels.

37. i.e. [+ATR] morphemes are dominant over [-ATR]. If the root is [+ATR] a variable suffix is [+ATR], otherwise it is [-ATR], but like Turkana Bari has a class of dominant [+ATR] suffixes:

lii	'eye teeth'	lii-te	'eye tooth'
kimor	'mosqui toes'	kimur-te	'mosquito'

The singulativizer suffix /te/ causes the whole word to be come [+ATR].

38. The difference between transparent suffixes like /j/ and dominant suffixes like /te/ (cf. fn. 37) is that the latter introduce a floating occurrence of [A]:

a. [A]	b. [A]
ji	te

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