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Soft stillness and the night become the touches of sweet harmony. Sit, Jessica.

The merchant of Venice, Act 5, lines 55/56

PHONOLOGICAL STRUCTURE AND THE NONLINEAR ANALYSIS OF VOWEL HARMONY

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0. Introduction

Consider the phonological rule under (1) on your handout:

(0.1) [+obs] -> [voice] / --- +obs
voice

This rule tells us that an obstruent must agree in voicing with an immediately following obstruent. Rules of this type are commonly found in languages across the world, and those of us who teach basic courses in phonology use them to illustrate the phenomenon of ASSIMILATION. Usually, we will say that it is not difficult to understand why assimilation takes place. Appealing to a notion like "ease of articulation", we will argue that the realization of two neighbouring segments requires less effort on the part of the speaker when the segments are more alike in their articulation.

This explanation probably makes sense to a beginning student as long as the segments in question are truly adjacent, i.e. not separated by intervening segments.

Suppose we encountered a case of voicing assimilation in which one consonant assimilated to another *across* an intervening segment, for example a sonorant consonant. An underlying voiceless obstruent would become voiced if followed by a voiced obstruent, with an optional intervening sonorant consonant, and, perhaps more surprisingly, an underlying voiced obstruent would become voiceless if followed by a voiceless obstruent, again with an optional intervening sonorant consonant. The second part of this rule is especially peculiar in view of the fact that sonorants themselves are voiced. A schematic representation of what seems to be going on can be found under (2):

(0.2) a. -son +son -son b. -son +son -son
-voice +voice ⊖voice +voice +voice ⊕voice ?

The phenomenon just described occurs in Russian, according to Jakobson (1978). Our first reaction might be that the ~~phenomenon~~ complication considered here only requires a slight reformulation of the rule under (1):

(0.3) [+obs] -> [voice] / --- X +obs
voice

Condition: X may contain [+cns, +son]

After all the theory we are articulating allows the specification of material which may intervene between focus and determinant.

But now, what about the explanation we have given for why assimilation takes place? Maybe the situation in (2a) can be accounted for by saying that although sonorants themselves are in some sense too weak to influence obstruents, they can do so if they get support from a neighbouring obstruent. But the situation in (2b) cannot be understood in this way. In fact (2b) is extremely curious in view of the fact that [-voice] is transferred across a segment which is itself [+voice]. Clearly our explanation for why assimilation takes place which appealed to the notion of adjacency no longer makes sense.

We can't get out of this uncomfortable position by claiming that the case of assimilation just described is a highly marked phenomenon (as if that would ever be the right thing to say). A moment of reflection will be enough to make us realize that there are many cases where we seem to be dealing with *action-at-a-distance*.

To stay with voicing for the moment, consider what happens in Kera, a Chadic language. In this language, it is generally true that all obstruents within a single root agree in voicing. In addition, obstruents in affixes are voiced if the root contains voiced obstruents, voiceless otherwise. In this case then, obstruents are influenced by other obstruents across sonorant consonants, glottalic consonants and vowels. Again it is not at all difficult to write a rule, which expresses what is going on:

(0.4) [+obs] -> [voice] / --- X +obs (mirror image)
voice
+ROOT

In this case it isn't necessary to condition the variable X, as anything may intervene between the segment affected and the trigger.

This last example is close in character to a whole array of phenomena, which are usually grouped under the heading of *vowel and consonant harmony*, and which quite clearly involve action-at-a-distance. Consider vowel harmony, the phenomenon which we will concentrate on today. Here it is practically always the case that consonants are totally irrelevant. This is easily accounted for by specifying a C sub zero between the target and the trigger of the rule:

(0.5) [+syll] -> [back] / +syll C_0 ---
back

Or, alternatively, we could condition the variable X, as in (6):

(0.6) [+syll] -> [back] / +syll X ---
back

Condition: X may contain any number of consonants

Writing a rule like (5) or (6) is one thing, explaining why consonants appear to be irrelevant is something quite different. For those who find it satisfying to say that features for vowels and features for consonants are different, in some sense still to be made precise, there is another question. Why it is that in some vowel harmony systems (for example that found in Turkish) some consonants, but not all, appear to be relevant, and why is it that in other systems (for example that of Finnish or Hungarian) some of the vowels appear to be irrelevant, such that we find back vowels imposing their backness value on suffixes across certain front vowels?

A phonological theory which allows us to specify optional material between target and trigger by using conditioned variables does not give an answer to such questions. Moreover, a theory of this type allows us to formulate phonological rules which nobody has ever found it necessary to formulate and which we do not expect to need in the future. For example a rule like that in (6) but with a different condition for the variable, for example the one in (0.7):

(0.7) Condition: X may contain at most 5 segments

Footnote
In addition to this, the theory gives us no explanation for the fact that although intervening material is sometimes tolerated, such that rules apply non-locally, other cases quite decisively involve rules which operate strictly locally.

Let me summarize the points made so far. A sensible explanation for assimilation appeals to the notion of adjacency, but a wide variety of phonological processes seems to involve segments which are not strictly adjacent. Moreover, in a subset of these cases the intervening segments may have a property which is contrary to the property which is transferred from the trigger to the target. A theory allowing us to use variables of the type illustrated above makes it quite easy to write the required rules, but the means employed are so powerful that the theory lacks explanatory ~~power~~ value.

In the face of this problem, some phonologists have proposed contraints on the use of variables. I will not go into the merits of these proposals, mainly because in the recent literature a number of proposals can be found which tackle the problem in a more interesting manner, namely by making the use of variables superfluous. It has been argued that cases where values are transferred across intervening segments, with contradictory specifications, can be reinterpreted in such a way that nothing is transferred at all. Others have taken a slightly different perspective and ~~have~~ have shown that, given certain assumption about incomplete specification, intervening segments are not really in the way because they have no specification for the feature which is transferred.

Proposals of the former type, which concern mainly vowel harmony~~, and in particular the issue of so-called neutral vowels~~, can be found in Goldsmith (1986) and in work done by Norval Smith and myself. The second type of approach, which covers a wider area, is known to me from lectures which Donca Steriade recently gave in Holland and a study in progress by Douglas Pulleyblank and Diana Archangeli. All this work depends in various ways on others who have developed the framework of autosegmental phonology, such as Nick Clements and Paul Kiparsky.

The~~se~~ two approaches mentioned are not in conflict and my main purpose today is to outline a way in which they can be combined. The work I report on here has for the largest part been done in close collaboration with Norval Smith. Time limitations prevent me from demonstrating in detail just how our approach differs from other, closely related approaches, and from proposals which differ more drastically from what we have in mind. However, along the way I will try to indicate concisely where we differ from other researchers, whose work has been indispensable in the development of our own ideas.

I have no doubt that many of you will recognize that the approach that I am about to outline shares a number of fundamental insights dating back to the work of Firth and others, and, in addition, incorporates important features of the phonological framework of Dependency Phonology, which has been developed by John Anderson, Colin Ewen and several others.

The structure of the remainder of this paper is as follows. I will first

outline very briefly the standard autosegmental approach to vowel harmony, focussing on the way in which vowels which fail to harmonize ~~(i.e. neutral vowels)~~ are handled. I this respect I will discuss a few alternative approaches, concluding that they are all inadequate. I will continue to propose an alternative, taking earlier proposals of Smith and myself as a point of departure. Thirdly, I will draw attention to a major difference between our approach and other approaches involving the nature of the feature system. In the fourth section, I will continue the exposition of our theory, drawing on the idea of organizing features hierarchically. Finally, I will mention some remaining problems.

(0.8) 1. The autosegmental approach to vowel harmony & the treatment of neutral vowels
2. An alternative approach
3. Single-valued features
4. The internal organization of phonological representations
5. Problems

1. The autosegmental theory of vowel harmony & the treatment of neutral vowels

The basic idea of the autosegmental theory of vowel harmony is that a property which is shared by segments within a particular domain, say the word, is extracted from the segmental matrix and assigned, as an autosegment, to the relevant domain. In Firthian terms, the shared property is extracted from the phonematic units and represented as a prosody.

The similarity with a Firthian approach is obvious, although I wouldn't go as far as Roger Lass, to whom it is not clear that autosegmental phonology "(despite its formal sophistication) [is] much more than a notational variant of prosodic phonology." (Lass 1984, 269) In this paper, I hope to make clear that autosegmental phonology offers an interesting elaboration of the common core of ideas shared with Firth's theory, not only as a result of formal sophistication, but also because of the attention which has been paid to the questions which I raised in my introduction.

This elaboration has lead to a major point of difference between the Firthian and the autosegmental approach. Autosegmental phonology is quite explicitly a theory of the nature of the relation between autosegments and segments, i.e. a theory of phonological representations. This involves among others that the way in which autosegments and segments are coodinated is spelled out and not left implicit, as in the Firthian approach. The original position is that this relation (called association) is predicted by a set of universal association conventions. A simple example is the following. In Hungarian we find a front-back or *palatal* harmony system. Let us for the moment say that all vowels are either front or back, and, suffixes have either front or back vowel depending on the root:

(1.1) gyujto - nek 'collector (dat)' gyujto - nak 'lighter (dat)

The autosegmental representation, is ~~as follows~~ given in (1.2):

(1.2) Lexical representation

-B	+B
gyUjtO nAk	gyUjtO nAk

Association conventions (AC)

-B	+B

gyujto nek gyüjtő nák

(I use here the notational convention to capitalize vowels which are unassociated to the autosegment which has been represented on a separate tier. The dashed lines represent the structural change resulting from the application of a rule or convention. The diagrams are not accurate in the sense that all phonological information, except for the harmonic feature is collapsed into a single "segmental tier". In section four, I will give you a more precise view on the nature of phonological representations in an autosegmental framework.)

The basic idea is that the autosegment is associated to a subset of the phonematic units in a directional fashion, going from left to right. As I said, the original position is that this is all a matter of convention, and although other areas where autosegmental theory has been applied may show evidence that it is more a matter of language-particular rules, I believe that this point does not carry over to vowel harmony.

Footnote
The directional, left-to-right procedure it not the only conceivable way of establishing an explicit relation between an autosegment and those segments for which this autosegment is relevant. In certain versions of autosegmental phonology this relation is established by a percolation device. On the assumption that strings of segments are hierarchically organized into a prosodic structure, the autosegment is assigned to some node in this structure. Consequently this feature trickles down to the relevant terminal elements. A variant of this approach is found in the theory of Dependency Phonology, which continues the tradition of the Firthian approach in that the precise way in which prosodies are related to terminal elements is considered to be a matter of phonetic realisation. Proposals of this type, to the extent that they are explicit, cannot handle certain opacity phenomenona, whereas the directional, and in this sense more linear, approach is more succesful in this respect.

Continuing with Hungarian, I must add that I have not, so far, represented the harmony system of this language accurately. It is in fact untrue that combinations of front and back vowels are disallowed. Ignoring words which have been called disharmonic or exceptional, we must acknowledge the fact that front unrounded vowels can cooccur quite freely with back vowels. Again I am concealing the whole truth. However, apart from cooccurring with back vowels, these front unrounded vowels have another striking property. Under certain conditions they fail to determine the backness of suffixes, even though they occur in the final syllable. This happens, firstly, systematically when they are preceded by a back vowel, and secondly, in a limited class of words if they occur alone or in combination with other front unrounded vowels.

(1.3) kocsi - nak 'carriage (dat.)' hid - nak 'bridge (dat)'

Due to their behaviour if the first example, front unrounded vowels have been called *transparent*. I will now first concentrate on the transparent behaviour of these vowels.

Let us consider the Hungarian vowel system:

(1.4.)	i	y	-	U	i:	y:	-	u:
			-		e:	o:	-	o:
	-				-			a:

Footnote
The behaviour of short /i/ in *kocsi* is also found for long /i/ and long /e/ and short / /. But not all vowels behave alike. While short /i/ is quite consistent in failing to condition harmony, this /i/ and /e/ are less so. In the case of /e/ we find reason to say that this vowel conditions harmony in the normal case.

From a phonetic point of view, we can say that the front unrounded vowels /i/ and /e/ and the low vowel /a/ all lack a harmonic counterpart in the long vowel system at the relevant height. Let us say that in such cases the harmonic opposition has been neutralized (without claiming any diachronic development). In the cases of /i/ and /e/ the neutralization product is the front member of the potential opposition, whereas in the case of /a/ the neutralization-product is the back member. We will call vowels lacking a harmonic counterpart *neutral vowels*. From a phonological point of view the low vowels and the mid vowels cannot be considered to be neutral, as /a/ and /e/ function as harmonic pairs (e.g. nak - nek 'dat.', na'l - ne'l 'next to'). The tension between phonetic and phonological neutralization has certain consequences for the harmony system which I will largely ignore here.

Words like *kocsi* could be called disharmonic. Yet this term is usually reserved for words which exhibit a combination of back vowels and front vowels other than /i/ or /e/. It is important to realize that such forms behave according to the following rule: the vowel in the final syllable determines the form of the suffix, as is illustrated in (1.5)

(1.5) soffor - nek buro - nak

The formal representation of such *disharmonic roots* is quite straightforward. Words of this type contain more than one autosegment, and in addition, lexical association of these autosegments to the relevant vowel:

(1.6) Lexical representation

-B +B	-B+B
soffor - nAk	buro - nAk
-B +B	+B-B
soffor - nek	buro - nak

The assumption,then, is that autosegments can be associated to particular vowels and still "spread" to other vowels. One can compare this the the Firthian notion of prosodies having a focus (cf. Anderson 1985).

The fact that it is the last vowel which determines the suffix vowel follows from the assumption that association lines can never cross. Of course there is no difficulty in making graphs with crossing lines. But if we ask ourselves what such a notation would express we would end up with a contradiction, in that our theory would allow one element both to precede and to follow another element.

Looking then at forms like *kocsi* one might wonder how such forms should be represented autosegmentally, so that the back vowel in the suffix is explained. The short history of autosegmental phonology has already seen a number of different solutions to this problem. I will discuss three approaches.

The first proposed way of dealing with cases of this type has been to start out with a representation which is the same as that assigned to real disharmonic roots, and to delete the [-B] value after a [+B] value. Consider stage 0 and 1 in (1.7). Alternatively one could leave out the speficiation for /i/ to begin with, starting out at stage 1. In any event, in both cases we derive an intermediate stage with an abstract vowel, i.e. a back unrounded vowel which does not occur in the segment inventory of Hungarian. Therefore the last step in the derivation is to front it again /ɨ/ by a rule of absolute neutralization.

(1.7) The abstract solution (Clements 1977)

+B −B	+B	+B	+B −B +B
kocsi nAk	kocsI nAk	kocs+ nak	kocsi − nak
stage 0	stage 1	stage 2	stage 3

This procedure is cumbersome, but, more seriously, it cannot be right. The implicit claim is that a vowel can only be transparent if it lacks a harmonic counterpart, i.e. step 3 is succesful because Hungarian lacks the segment /+/. It happens to be true however, that the lack of a harmonic counterpart is not a necessary condition for transparent behaviour.

We know several cases where vowels act transparently despite the fact the language in question has the appropriate harmonic counterpart. This is what happens in Finnish, for example, where the front rounded vowels /y/ and /ö/ can act transparently in a careful style of speech, although the language has /u/ and /o/:

(1.8)

martyyri-us	martyyri-ys
(careful style)	(casual style)

In fact, the transparent behaviour of /e/ ~~(long or short)~~ in Hungarian shows the same point, as the harmonic counterpart of these vowels is /a/, a vowel which actually occcurs.

To broaden the discussion, consider a third example which involves harmony based on the feature [Advanced Tongue root]. In Bari, a Nilotic language, we find the following cases, as reported in Hall and Yokwe (1978):

(1.9)

a.	w r	'go'	w r − ji − ne?	'be gone'
	kam	'paddle'	kama − ji − n ?	'be paddled away'
b.	r ng	'reproach'	r ng − un − dya	'take away by force'
	dir	'carry between two'	dir − un − dy	'carry this way'

To avoid any possible misunderstanding, let me quote Hall and Yokwe, who say:

> "In certain cases a verbal morpheme which is subject to vowel harmony follows a derivational morpheme which has a [+ATR] vowel but does not cause harmony to itself. In these cases, the harmonic series is maintained from the root across the intervening morpheme." (p.290)

The crucial point is that /i/ has an harmonic counterpart, /i̘/. Compare for example the two verbs under (1.9b). The analysis involving an abstract stage cannot be maintained then, as demonstrated in (1.10)

(1.10)

−A	−A	−A +A −A
kAm − jI − nE	kama − ji − n ?	kama − ji − n
stage 1	stage 2	stage 3

The rule "restoring" the /i/ in stage 3 cannot simply apply to any /i̘/. The abstract analysis could only be maintained if we allow the neutralization rule to make reference to ~~the~~ specific instances of the vowel /i/, causing the need for rule features.

A second ~~approach~~ issue of dealing with transparent vowels is based on the assumption that segments which, due to constraints on segmental structure, should not be associated to an autosegment particular

are skipped over. So in Hungarian we have a segment structure condition which is expressed in (1.11a):

(1.11) a. NOT [+back, -round, -low] (i.e. NO back unrounded nonlow vowels)

b. [-round, -low] -> [-back]

This condition is part of any grammar of Hungarian, as it is a true statment about the segment inventory of this language.

Under this approach we assume that a vowel like /i/ is underlyingly represented as being unassociated to [-B]. Occuring in a root like *kocsi* it cannot be associated to the [+B] autosegment present in this root and it will therefore be skipped:

(1.12) The "skip solution" (Kiparsky 1981, Van der Hulst 1985, Steriade 1986)

+B	+B	+B -B +B
kocsi nAk	kocs+ nak	kocsi nak
stage 1	stage 2	stage 3

This approach shares with the previous approach that after association has taken place a rule "breaks up" the harmonic span and links [-round, -low] vowels to [-B]. The relevant rule is the one in (1.11b).

Again, it can be shown that this approach cannot be correct.

Consider first the Finnish example. In this case, we cannot prevent a spreading [+B] from associating to the underlying representation of /y/ in term of a segment structure condition. There is no SSC ruling out the harmonic counteraprt of /y/, since /u/ is a segment of the langiage. Steriade therefore assumes that VH applies cyclically. Associating [+B] to the second syllable of *martyyri* is then prevented by the Strict Cycle Condition, which prevents rules from applying in environments which are not morphologically or phonologically derived. The [+B] cannot be associated to the second vowel due to the Strict cyle condition, nor to the third due to a segment structure condition. Hence both vowels are skipped and the autosegment directly links up with the suffix vowel.

(1.13)

+B	+B	+B -B-B +B
martUUrI - Us	martUUrI - us	martyyri - us
stage 1	stage 2	stage 3

/yy/ gets its specification by a default rule, a point to which we will return below.

However, the example from Bari cannot be handled in this way. Consider again (1.10). The suffixal high vowels constitute a derived environment and the the Strict cycle condition will therefore not prevent [-A] from associating to them.

Summarizing, we can say that existence of certain types of transparent vowels, namely those which are not neutral in the technical sense that they lack an harmonic counterpart, present insurmountable problems for an autosegmental approach. Indeed, this is a point made as far back as 1980 in an article by Stephen Anderson, who concluded that vowel harmony cannot be treated as an autosegmental phenomenon and must be dealt with segmentally, as in the Sound Pattern of English.

The third approach attempts to compromise between the autosegmental and the segmental analysis. I will call it either the segmental or the *tier duplication* approach:

(1.14) The Tier Duplication approach (Hart 1981, Van der Hulst and Smith 1982, Booij 1984, Lieber 1985, Spencer 1986)

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      +B                    +B

kocs i  nek          kocs i  nak
   -B                    -B
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The fundamental idea is that a feature can be present on more than one tier at the same time, and that segments may associate to either of these tiers. In less technical terms, all different variants of this approach boil down to claiming that certain segments can have a segmental specification for a feature which has otherwise been autosegmentalized.

A moment reflection shows that this approach can cope with cases in which we have transparency without neutralization of contrasts. The /yy/ in martyyri*and* the high vowel suffixes in Bari will have segmental specifications for [Back] and [ATR] respectively. We now only have to assume that segments already specified for a particular feature are skipped by the autosegmental variant.

2. An alternative approach

The segmental approach involves a rather drastic change in the autosegmental theory. In this section, I will argue that all transparency effects can be handled without changing the theory in this way.

Before I develop this alternative, let me draw attention to another problem which exists for all the approaches discussed sofar, i.e. both for the two autosegmental approach and for the segmental approach. As I will show, the problem can be solved in a pricipled way, but it then turns out that the segmental approach just outlined can be avoided. To put it differently, by solving the problem we are about to discuss we also get rid of the problem of dealing with transparent vowels.

The problem is, in a nut shell, that the approaches just seen cannot explain why certain types of harmony systems don't occur.

We have seen that in Hungarian and Finnish front unrounded vowels act as transparent. In addition front rounded vowels can also be transparent in Finnish. As far as we know, only front vowels can be transparent in palatal harmony systems. No harmony system based on ~~palatality~~ frontness has transparent back vowels. If back vowels are invariant they always act as opaque.

In ATR systems, as far as transparency occurs, we always find that the transparent vowels are [+ATR]. The invariant high vowels in Bari are a case in point. Invariant [-ATR] vowels are always opaque. Similar observations can be made with respect to rounding harmony, where transparent vowels are rounded and unrounded vowels opaque, and in lowness harmony, where transparent vowels are low and non-low vowels opaque. In the last two cases, the observations are ~~more tentative~~ numerous less and the crucial cases need more careful study. The table in (2.1) summarizes the observations just mentioned:

(2.1)

Harmonic feature	Transparent	Opaque
FRONT	FRONT	BACK
ATR	ADVANCED	RETRACTED
ROUND	ROUNDED	UNROUNDED

LOW LOW NONLOW

Below, I will discuss the formal representation of opacity. First I want to show you that the approaches we have discussed so far cannot explain the correlations in (2.1). Why this is so can be seen quite easily if we imagine for every case discussed a second case where all plusses have been changed in minuses and vice versa. We simply get reverserd situations with back vowels being transparent. Consider as an example the segmental approach.

It is easy within this approach to represent a word in which back vowels rather than front vowels are "transparent":

(2.2)

-B		-B
bur o	nAk	bur o nek
+B		+B

Analogues of this could be constructed for the other two approaches.

These approaches then predict harmony systems with transparent front and back vowels, even within one and the same language. I will now show how the correlations between invariant feature value and behaviour as either opaque or transparent can be explained. I will proceed in two steps, starting with a proposal which follows from current ideas about phonological underspecification. I will argue that, although underspeficiation theory offers a step in the good direction, a more principled approach involves the use of single-valued features.

Suppose then we were to say that [+back] and [-back] are not equivalent in that one is the marked value, and the other the unmarked or default value. Kiparsky (1982) suggests that each feature is universally supplied with a default value. In addition he has suggested that lexical representations are not burdoned with the default values. Rather these are filled in at some later stage in the derivation. Pending the discussion about how we establish what the marked or default value is let us see what consequences could be drawn from a particular choice.

Suppose we assume that for the feature back "-" is the marked value. Hence the lexical representations contains only the minus value, which for this reason I will simply call the LEXICAL VALUE. Note that not all lexical values need be present, since some of them may be predictable on the basis of other feature specifications. So in the case of Hungarian minus for backness, or to put it positively, frontness is specified in the lexicon, but for /i/ even this is predictable. So nonlow unrounded vowels have no specification for the feature [Back].

Within the segmental approach it will be clear that, given this set of assumptions the impossibility of back transparent vowels is accounted for because we cannot prespecify a vowel as [+back], such that it will be skipped when spreading [-B], if the value + can not be specified lexically.

Surprisingly, and fortunately, the decision to represent only frontness in the lexicon has eliminated the need for having segmental specifications. To realize this we only have to show how in the present approach suffixes acquire a backness value after a stem like *kocsi*. For comparison, I have added a derivation showing how a transparent vowel behaves in a front vowel root:

(2.3) The underspecification approach

-B

kOcsI nAk tOmEg nAk

-B

AC

kOcsI nAk tomeg nek

-B

rule 2.4

kOcsi nAk tomeg nek

-B

rule 2.5

kocsi nak tomeg nek

Back vowel roots lack an autosegment. Hence in the left-hand example no spreading take place across an intervening front unrounded vowel. Two rules apply to supply vowels which remain without an association to a backness value. Firstly, we have a redundancy rule which suplies unrounded nonlow vowels with the specification [-Back] and secondly we have the default rule which assign [+back] to all other ~~cases~~ vowels.

(2.4) [-B]

V -> V
-low
-round

(2.5) [+B]

V -> V

The prior application of (2.4) follows from general principles such as the Elsewhere Condition.

Footnote. Observe that it in no way essential that /i/ receives its [-B] specification late, except for the fact that if we specify it early, we must somehow prevent its [-B] specification from spreading. Below we will return to this point.

It will be clear that we no longer have to commit ourselves to specify /i/ or /e/ as [-back] at the segmental level in either Finnish or Hungarian. The ~~Observation~~ that we have of [+back] spreading accross a [-back] transparent vowel, appears to have no theoretical foundation.

The present approach differs ~~in~~ from one important respect from the other approaches discussed above. In these, the backness of the suffix vowel is attributed to the back vowel which precedes the /i/. This is not the case in the underspecification approach. In this case the backness of the suffix vowel is due to the fact that there simply is no feature to spread onto the suffix vowel. This point ~~outlined~~ finds confirmation from the following fact. Words may also consists of only front unrounded vowels and suffixes which are atttached to such front vowel roots usually show up with a front vowel. As I already have mentioned, there is a limited class of front vowel roots after which we find back suffixes. Within our approach the difference between these two types of roots is represented as follows:

(2.6)

		-B	+B		-B		-B
		=>				=>	
hId	nAk	hid	nak		vIz	nAk	viz nek

In the three other approaches, sketched above, the hid-class requires some special treatment. Hence our theory is not only more constrained, it also simplifies the analysis, reducing two facts to one.

Footnote
The fact that /i/ has a predicatble value for backness does not preclude the possiblity that it occurs in a root which contains [-B].

back vowel root	front vowel root
	-B
hId	vIz

To prove that the autosegmental theory has been saved, we must demonstrate that the phenomena which were earlier presented as problematic no longer are. You will recall that we rejected both variants of the autosegmental approach by pointing out that in certain cases the vowel acting as transparent need not lack an harmonic counterpart. Since such vowels do not have a predictable value for the harmonic feature, we cannot leave them unspecified in the lexical representation. We have seen that such vowels do not cause harmony, unless they are preceded by a root with advanced vowels. Now the only thing we want to say is that values associated to the invariant vowels don't spread. Instead of adopting a segmental specification to encode this, let us simply say that such features are lexically associated and let us adopt the convention that autosegments which are associated in underlying representation are not subject to automatic spreading. This is no more stipulative then saying that certain segments are segmentally specified. The point is that we don't need segmental specification if the only thing we want to say is that we are dealing with a non-spreading feature.

(2.7) a.

+A	-A-A	+A -A
kAmA - ji - nE?	kama - ji - n ?	

b.

+A +A	+A	+A
wArA - ji - nE?	wArA - jI - nE?	w r - ji - ne?

In addition we need one extra device to allow spreading to take place across a segment which is itself specified for the spreading feature. We might think of this in the following way. Although we assume that an associated autosegment doesn't spread by convention, it will spread if its autosegment in set afloat.

(2.8)

+A +A	+A +A	+A +A
wArA - ji - nE?	w r - ji - nE?	w r - ji - ne?

Footnote
To return to a point made above, note that it is indeed no longer essential that we assume transparent segments to be unspecified, even if their value is predictable.

Footnote

Constructing an example in the case of Hungarian involves the formation of diminutives from proper names:

Klara klar + i + nak

Tibor Tib + i + nek

Footnote
We don't predict that in a harmony system of this type front vowels could not act both as non-spreaders AND blockers. This is possible if front vowels could be argued to be non-triggers. Like /u/ in Khalkha which can't trigger rounding harmony, and which blocks roundiness spreading. Below we will turn to this system.

At this point, I must turn to the formal treatment of opacity, ~~not only for the sake of completeness, but also because~~ some of you may realize that lexical association, the charactistic of transparent segments under our approach, is precisely the way to represent opaque segments.

Starting again with palatal harmony, let us consider the case of Rumanian. According to Donca Steriade, Rumanian has frontness harmony. Rumanian has the following vowel system:

(2.9) a. i –
e –
–

+ u
ə o
a

b. NOT [+round, -back]
[+low, -back]

This system shows certain gaps which are expressed in the segment structure conditions, given under (2.9b).

The nonlow back unrounded vowels alternate with front vowels in the context of front vowels, unless a back unrounded vowel intervenes. As expected, the vowels which are invariably back, i.e. which have no front counterpart, are opaque. This follows straightforwardly if we simply assume that vowels cannot be skipped, i.e. if we assume the following universal convention:

(2.10) NOT F
V V V

The segment structure conditions will prevent the spreading [-back] from associating to the vowels which are opaque, and the condition will prevent them from being skipped. Hence their opacity is accounted for. Vowels following the opaque vowels cannot be linked to the spreading feature and they will surface with the default value. (Observe that in this account opaque vowels are blockers, but not spreaders, since they have nothing to spread.)

A quite analogous case can be constructing for ATR harmony. In many systems based on ATR we find certain gaps in the vowel system.

(2.11) a. advanced vowels non-advanced vowels

i u
e o
a

b. advanced vowels non-advanced vowels

i u
e o
– a

c. NOT [+low, +ATR]

To the best of my knowlegde it is always true that the low [-ATR] vowel will act as opaque, rather than anything else. A case point is the vowel harmony system of Akan, as it has been analyzed in several articles by John Stewart.

The opacity of the low [-ATR] follows striaghtforwardly if it is assumed that [+ATR] is the lexical value. This value cannot spread to low vowels due to the condition in (~~1.25c~~ 2.11c) and due to the no-skip condition it cannot any further.

Before I proceed let me sum up the points which have been made.

Firstly.
An approach which makes use of underspecification in the sense that for each feature only one value is specified lexically is capable of dealing with both transparency and opacity effect caused by the presence of certain invariable vowels,

Secondly.
Given certain assumptions about which value is specified lexically, we predict the non-existence of certain harmony systems, whose absence would otherwise be accidental. To be more specific, we predict that only vowels which invariantly have the lexical value can be transparent, and furthermore that vowels which invariably have the default value must be opaque.

Thirdly.
This approach allows us to maintain that all spreading is strictly local in the sense that it cannot skip vowels.

3. Single-valued features

At the end of the preceding section, I said that the assymmetrical distribution of neutral segments can be explained, given certain assumptions about which value is specified lexically. By saying this, I have drawn your attention to a basic weakness of the underspecification approach. Given that each feature is binary valued, it would in principle be possible to have a vowel harmony system in which back vowels, rather than front vowels are transparent, I have claimed that such languages do not exist. Clearly then the underspeficiation approach is still too weak.

So let us assume that instead of having [+back] and [-back] we have a single feature, indicating one of the poles of this dimension, and furthermore that the choice for which pole is represented is universally determined. We could either select Front or Back as a single-valued feature. If we now turn back to the treatment of Hungarian vowel harmony, we can see that the treatment of transparent vowels crucially depends on specifying frontness underlyingly: transparent vowels didn't pose a special problem precisely because they have the value which is specified lexically. It would appear then that ~~we should opt~~ must choose for frontness as being represented by a single-valued feature. This finding ties in nicely with proposals concerning the nature of single-valued feature systems which have been advanced within the framework of Depedency Phonology and elsewhere.

DP has four basic features:

(3.1) The set of vocalic features in Dependency Phonology
{[I], [U], [A], [ə]}

The features are front represented as [I], rounded (or peripheral), represented as [U], low represented as [A] and "central", represented by [ə].

The vowel system in (3.2a) is simply represented as in (3.2b):

(3.2) a. /i/ /u/ b. {[I]} {[U]}

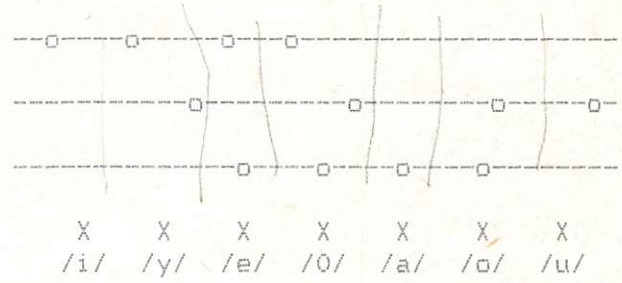
/a/ {[A]}

A vowel which is high, front unrounded is now quite simply and exhaustively represented as specified with the feature [I]. More complicated vowel systems involve segments whose feature specification is more complex. For example, mid vowels are "mixed" in that they combine properties represented by the features mentioned. For example a mid front unrounded vowel /e/ is represented as {[I], [A]}, a front high rounded vowel /y/ is represented as {[I], [U]}. In (3.3b) one will find a autosegmental notation for the vowel system in (3.3a):

(3.3) a. /i/ /y/ /u/ b.

/e/ /o/ /o/

/a/



The shorthand notation adopted here is that a vowel specified for I-ness is associated to the I-line. All tiers are directly associated to a skeletal slot.

Recently Lass has criticized the particular feature set adopted in DP. The specification of back unrouded vowels in particular raises certain problems. The proposals found in recent DP work is to specify for example a high back unrounded vowels as in (3.4):

(3.4) {[I], [U], [ə]}

This proposals casts doubt on the appropriateness of interpreting [U] involving roundness, among others. Lass proposes to redefine [U] as representing backness only, by splitting of rounding as a separate feature, here represented by a capital [R]. At the same time Lass maintaines the centrality component. But this is unnecessary since now centrality can be specified in terms of [I] + [U]. Below, I will adopt Lass' proposal to factor out rounding for completely different reasons.

Another central notion in DP appoaches which I would like to critisize is that dominance relations hold among features. In this system a mid vowel is characterized as being both [I] or [U] and [A]. However languages may have two rows of mid vowels. How are these characterized? In terms of dependency relations:

(3.5) a. I governs A : /e/ A governs I: /E/

Another way of classifying the two height differences is by means of an extra feature, Advanced Tongue Root, which is necessary in any case to deal with languages which have ATR harmony. For practical purposes, I use [E] to represent ATR. Think of this as an abbreviation of [Expanded Pharynx], a name which, according to some, covers better the phonetic content of the feature in question.

(3.5) b. /e/ {[I], [A], [E]} /E/ {[I], [A]}

We end up with the following system of features:

(3.6) Feature set adopted here:
{[I], [U], [A], [E], [R]}

Footnote
This system is close to that of Rennison (1986), except for the fact that his features are binary valued.

There are of course several reasons for choosing Advanced rather than Retraced tongue root as primitive, and Round rather than unround. Here I want to stress that these choices make the right predictions with respect to the way in which neutral segments may behave. Thus, given that roundess and advancedness are the lexical values we predict that only round and advanced segments can act transparently, and, furthermore, that unround and unadvanced vowels must act opaquely. To a large extent these predictions are born out, as we have seen in the preceding section. In the case of rounding harmony there is one notorious problem to which I will turn in the next section.

As an illustration of how this feature set can be used, let me consider in considerable detail the case of Hungarian. The Hungarian vowel system can now represented as follows:

(3.7)

	{I,E}	{I,E,R}	–	{U,E,R}
	/i/	/y/		/u/
–		{I,E,A,R}	–	{U,E,A,R}
		/o/		/o/
	{I,A}		{A}	
	/e/		/a/	

The cooccurrence restrictions on feature combination which hold in the above system are the following. I will refer to such conditions as segment structure conditions:

(3.9)
a. NOT: [U] & –[R] (No back unrounded vowels)
b. NOT: [I] & [U] (No central vowels)
c. NOT: [E] & –([I] v [U]) (No low, advanced vowels)
d. NOT: [R] & –[E] (no rounded low vowels)

We can use these conditions to leave out a number of features. But we have more than one option. In any event we can leave out [R], whose presence can be predicted on the basis of [U], the rule in (3.10) is of course logically equivalent to the negative condition in (3.9a). On the assumption that violations of structure conditions are eliminated by the minimal addition of features, we can say that rule (3.10) need not be stated explicitly:

(3.10) [U] –> [R]

Now the logical equivalent of (3.9c) is:

(3.11) [E] –> [U] v [I]

Which implies that we can leave out either [I] or [U] for those vowels which

are [E]. Only by leaving out [U] can we arrive at a unary statement about vowel harmony for both vowel heights. In both cases the alternation will involve [I] versus nothing. I will assume that a rule like (3.11) will assign [U] rather than [I], as the latter feature is already present in the lexical specification of other segments. Due to condition (3.9c) [U] cannot be assigned to segments specified with [I].

A specification of the Hungarian vowel system, which takes the above mentioned redundancies into account is as follows:

(3.12)	{I,E}	{I,E,R}	-	{E}
	/i/	/y/		/u/
	-	{I,E,A,R}	-	{E,A}
		/o/		/o/
	{I,A}		{A}	
	/e/		/a/	

In fact however, leaving out [R] in the back vowel series raises a problem. We would predict that the front counterparts of /u/ and /o/ are /i/ and /e/ rather than /y/ and /ö/, rounding being only possible if the preceding front vowels were round. Clearly this implies that back vowels must be specified for [R].

Footnote
In Chamorro back rounded and front unrounded vowels are harmonic counterparts. Here then [R] is unspecifed for back vowels.

/i/	/u/	{[I],[E]}	{[E]}
/e/	/o/	{[I],[A],[E]}	{[A],[E]}
/ae/	/a/	{[I],[A]}	{[A]}

[E] -> [U]
[U] -> [R]

#

In one case however, we do get underlying absence of [R]. Certain suffixes shows a three-way alternation, rather than a two-way alternation:

(3.13) /ɛ/ - /a/ /ɛ/ - /ö/ - /o/

Clearly the underlying source for both cases must be different and we suggest the difference is as follows:

(3.14) {[A]} {[A], [E]}

The treatment of three-way alternation proceeds as follows. The underlying specification of the /e-o-o/ alternation is {[A],[E]}. After a front vowel [I] is added, after a rounded vowel [R] is added. The problem has always been to account for the occurrence of /o/ after /a/ and non-spreading front unrounded vowels. In this position rules (3.10) and (3.11) apply, thus creating /o/. The fact that we have to fill in [U] for this alternation is consistent with the choice for leaving out [U] rather than [I]. This analysis derives a non-low short /e/, which implies that a rule of phonetic detail must apply to erase [E] in the required case.

(3.15) NOT: (X & [I] & [A] & [E]) & -[R] ("X" means "short")

[E] -> 0

This deletion rule must be stated as other possiblities are available to eliminate violations of this conditions. In fact, we need other phonetic segment structure conditions and associated rules.

Short and long /e/ and dito /a/ differ in there phonetic properties in that short /e/ is lower than long /e/ and short /a/ is backer and more rounded than long /a/. I have assumed that the phonological classification abstracts away from these differences.

(3.16) a. NOT: (XX & [I] & [A]) & -[E]

0 -> [E]

b. NOT: (X & [A]) & -[U]

0 -> [U]

In these cases the phonetic SSC's imply a unique rule which remedies violations by the minimal addition of a single feature. Hence in this case these rules need not be stated in the grammar.

Footnote
We cannot leave out [I] for the front unrounded vowels, because then the rule filling [I] and [U] in must be:

[E] -> [U] / [R]
[I]

But this rule wouldn't specify [U] in the rounded harmony suffixes, which crucially lack [R] and acquire this specification on the basis of [U].#

Observe finally, that, strictly speaking, the feature [E] too is redundant in the classification of the Hungarian vowels. However, the relevance of this feature in underlying representations has just been motivated by the analysis of rounding harmony.

Footnote
The Rumanian system in single valued features

{I,E}		{U,E}	{U,E,R}
/i/	-	/+/	/u/
{I,E,A}		{U,E,A}	{U,E,A,R}
/e/	-	/&/	/o/
		{A}	
-		/a/	

NOT: [I] & [R] (No front rounded vowels)
NOT: [E] & -([I] v [U]) (No low advanced vowels)
NOT: ([I] v [U]) & -[E] (No non-low retarcted vowels)

We can leave out [U] from the underlying representation:

[E] -> [U]

Footnote
In this approach the treatment of a full harmony system is as follows:

/i/	/y/	/+/ /u/	{I,E}	{I,R,E}	{E,U}	{U,E,R}
/e/	/O/	/a/ /o/	{I,A,E}	{I,A,E,R}	{A}	{U,A,E,R}

To analyze the harmony in terms of [I] spreading, we'll have to say that [U] is not specified. Note that again we could also leave out [I] and analyze the harmony as U-Harmony, but that then we have now single statement for harmony among high and low vowels, unless we specify the low vowels with [U].

If /+/ drops out we can still analyze it as either IH or UH:

NOT [U] & -[R]

By choosing UH (maintaining our original ideas about transparent/opaque) we predict that a system lacking /+/ has opaque /i/.

If /y/ drops out we say:

NOT [I] & [R] or NOT [R] & -[U]

I-spreading will cause /u/ to be opaque. U-spreading will treat it as transparent.

The problem with leaving out [I] rather than [U] is (also again) that U-spreading doesn't generalize over both vowel height. In the low vowel section, only I-spreading is possible, given that /a/ pairs with /e/ (/a/ lacks [U]).#

Before we turn to a further elaboration of the present approach, I want to make a few remarks about the phonetic background of the feature system proposed here.

The system of vowel classification which has been prevalent since the days of Bell and Sweet is that which takes the position of the tongue arch as the defining criterion.

In this view the top of the tongue arch can move up and down, backward and forward and it can take an intermediary position on both dimensions. A system of binary features including [High], [Low], [Front] & [Back] can be used to indicate 9 vowel positions. All can be rounded or unrounded, giving us 18 vowels:

(3.17)

	+front,-back		-front,-back		-front, +back	
	-round	+round	-round	+round	-round	+round
+high -low	i	y	i	u		u
-high -low	e					o
-high +low						a

This system is referred to a bidirectional binary valued.

In recent years, a number of phoneticians have argued that the tongue-arch model is wrong, ~~since~~ primarily because it has no physiological basis. It is important to note

that the criticism didn't concern the classification as such. Some phonologists have given up the idea that features can be defined in an articulatory fashion, others have developed an alternative system of articulatory classification in term of constriction locus.

A proposal of the latter type is found in Wood (1982). On the basis of the feature set proposed by him, I come to the following phonetic interpretation of my feature set:

(3.18)			
	I	[+Palatal]	"palatal constriction"
	U	[+Velar]	"velar constriction"
	E	[-Pharyngeal]	"pharyngeal expansion"
	A	[+Open]	"open jaw"
	R	[+Round]	"rounded lips"

There are major differences between Wood's proposals and mine. Firstly, my features are single-valued. In addition, I use the feature for pharyngeal width differently from Wood and more in the sense in which Svantesson (1986) uses Wood's system.

Footnote
Furthermore, Wood combines the features differently.

/i/	/y/	/u/	{I,E}	{I,R,E}		{I,U,E,R}
/e/	/O/	/o/	{I,A,E}	{I,A,E,R}		{U,A}
	/a/				{A}	

The articulation of /u/ is "palato-velar" and that of /o/ "velar-pharyngeal".

The difference between /i/ and /I/ is made here by [+/-pharyngeal], and not by [+/-tense], following Svantesson.

An immediate consequence of this system is that IH becomes UH, which turns the way in which the behaviour of neutral vowels is explained on its head. Consider a full harmony system, as that of Turkish:

/i/	/y/	/+/	/u/	{I,E}	{I,R,E}	{I,E,U}	{I,U,E,R}
/e/	/O/	/a/	/o/	{I,A,E}	{I,A,E,R}	{A}	{U,A,R}

An advantage of this system is that [I] is virtually identical to [+high].

In the high vowels harmony consist in "adding [U]. If /+/ drops out this means that /i/ must be skipped (NOT: [U] & -[R]), i.e. [U] cannot link to something which is not [R]. If /y/ drops out (NOT: [R] & -[U]) we must say that a vowel which is obligatorily associated to [U] blocks. The whole idea of not having discontnuous association must be given up.

However, apart from this, note that we have no uniform treatment of VH anymore. The difference between the low vowel pairs is "add [I]" (for /e/-/a/) and "replace [I] by [U]" (for /O/-/o/).#

This brief excursion ~~on phonetics~~ suggests that a rethinking of the feature system both in phonetic and in phonological quaters leads to results which in principle are compatible.

4. The internal organization of phonological representations

In this section I will discuss cases in which harmony spreading ignores certain segment types. In this case, I will argue that these segments are truly skipped. Yet, although this must seem contradictory, they are skipped without violating the condition against discontinuous association.

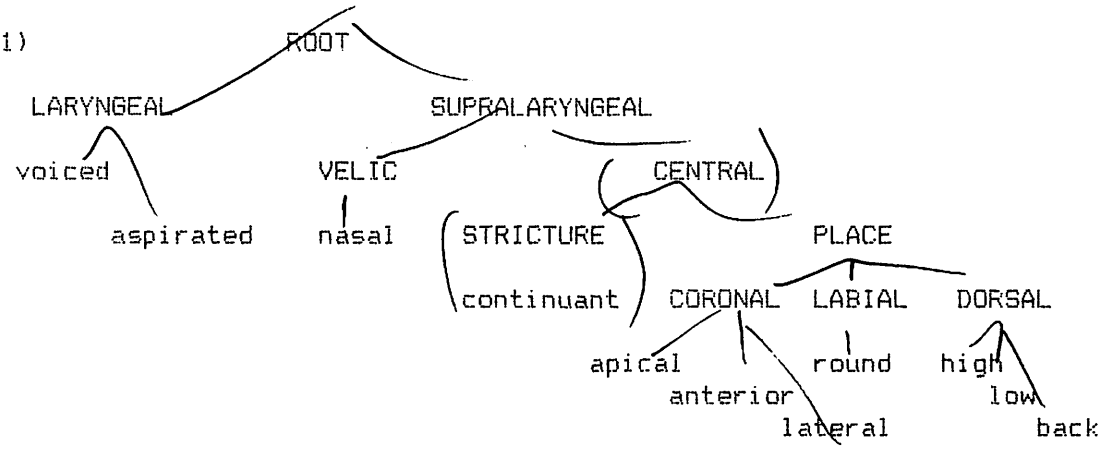
4.1. The skipping of /i/ in Khalkha Mongolian rounding harmony

A point which I have been ignoring up to now involves the "transparency" of consonants. Why is it that consonants are ignored in most cases but not in others. The answer to this question which I find the most interesting at the moment is that given by Steriade, who draws upon recent elaborations in autosegmental theory concerning the infrastructure of phonological representations. I cannot go into the motivation behind the relevant proposals in great detail, but, as before, I am sure that many of you will be familiar with the ideas involved here, as not dissimilar views are implicit in the idea of subclassifiying phonological features, or explicit in other schools such as DP.

The essential point is that the subclassification of features, implied by such labels as "place feature", "manner features", "tonal features" etc. is formally represented by assigning a hierarchical organization to the set of features. In terms of DP: the internal structure of segments involves subgroupings of features, called gestures.

For example Clements (1985) proposes an internal organization along the following lines. We find gestures, and subgestures, which in his terminology are called class nodes:

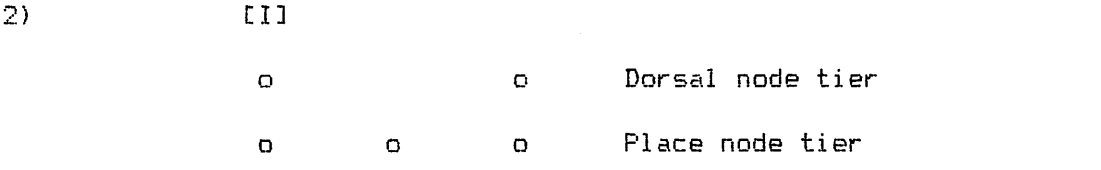
(4.1)



The details of this proposal need not concern us here. What is essential is that the intermediate nodes are part of the formal representation of segments.

Consider now what consequences this mode of representation has. Observe that the vocalic features are grouped under a dorsal node (ignoring the feature round for the moment). These features are usually not distinctive for consonants. In the spirit of underspecification, we might therefore say that consonants are not only unspecified for these features, but that they lack the dorsal node altogether. Assuming then that spreading does not lead to node creation, we can say that for the purpose of spreading of, let us say [-back], consonants are simply not there:

(4.2)



Not only have we now explained that consonants are skipped, but we also stay in line with the requirement that discontinuous association is disallowed. The spreading of [I] involves adjacent nodes. The condition against discontinuous association must be interpreted such that it rules out association across an intervening segment which is a P-bearing unit for the feature in question.

At this point we must return to the account of opacity. Recall that we have said that a segments is opaque if it cannot be associated to a particular feature which is being spread. We must now add that this presupposes that such segments have the relevant class node to which the feature in question associates.

For example, take the low vowel in Akan. This vowel cannot be associated to [E]. So why can't [E] simply ignore this vowel. Well, because the low vowel is specified with another feature namely [A], which associates to the C-node to which [E] also associates. We must assume then that [E] and [A] associate to the same class node.

By the same reasoning we can show that Rumanian /u/, /o/ and /a/ are P-bearing with respect to [I] although none of these vowels can actually be associated to this feature. We must assume that the features which specify the opaque vowels associate to the class node to which [I] also associates. This leads to the conclusion that the features in (4.3) all associate to the same class node.

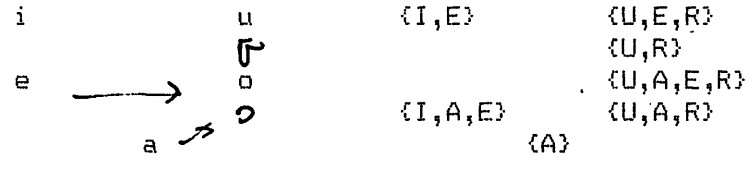
(4.3) [A] [E] [I] [U]

o

I would now like to offer evidence from the harmony system of Khalkha Mongolian that the remaining feature [R] associates to a separate class node, as has been suggested in the proposals by both Clements and Steriade on the basis of other arguments.

KM has the following vowel system, according to the analysis presented in Svantesson (1986):

(4.4)



KM has rounding harmony. Low vowels agree in rounding ~~harness~~ and this is still true even if the vowel /i/ intervenes. No harmony is required if low vowels are separated by a high rounded vowel. After high rounded vowels low vowels must be unrounded. The essential point is that /i/, an unrounded segment, acts transparently with respect to roundness spreading.

I would like to claim that we can ~~now~~ explain why /i/ can be skipped and why /e/ cannot, and why /u/ and /U/ are blockers, but not spreaders.

Observe that in KM the vowel /i/ has no harmonic counterpart, i.e. the vowel /y/ is lacking. This fact is expressed in condition (4.5a):

(4.5) a. NOT: [I] & [R]
b. NOT: [U] & -[R]
c. NOT: [R] & -[U]

Also, we see that either [U] or [R] is redundant. Since KM has rounding harmony we will assume that [U] is absent.

In this case the feature [R] is not distinctive for segments which are [I], and, since there is no more than one feature rooted in the labial class node, such segments can be represented without this class node. This implies that the vowel /i/ is not a P-bearing segment unit for the roundness feature, which explains why it is skipped.

[Incidentely, we expect that /e/ is skipped too, which it isn't. But since /e/ is the unrounded counterpart of /o/ and the ATR counterpart of /a/, it must not be specified as [I] to begin with, but simply as {[A], [E]}.]

We must also explain why /u/ and /U/ are blockers. As I said, rounding harmony is triggered and undergone by vowels which are low, i.e. [A]-specified. This makes the high rounded vowels, non-spreaders, non-undergoers and blockers.

In (4.6) it is shown why /i/ gets skipped and why /u/ and /U/ are blockers.

(4.6)

[R]			[R]	[R]	
o		o	o	o	labial
X	X	X	X	X	
o	o	o	o	o	lingual
[A]	[I]	[A]	[A]	([E])	[A]

This analysis of KM and in particular of the skipping of /i/ draws on the possibility of leaving certain class nodes "unspecified", thus enabling them to be ignored.

4.2. [A] harmony

I would now like to present a speculative extension of the approach just outlined. So far we haven't talked about harmony based on vowel height. In our terminology this would be [A] harmony.

[Footnote
I am aware of A-harmony in the following cases: some Togo-rest languages, Menomini, Pasiego, Salentino, Nez Perce, Middle Korean, Chuckee.]

The case of Pasiego, recently discussed in McCarthy (1985) and reanalyzed in Spencer (1986) involves a transparent /a/. The transparency of /a/ in Pasiego poses no particular problem. An element specified with [A] can be transparent with respect to [A] spreading.

More interesting for the present discussion is the fact that in Nez Perce the vowel /i/ is being skipped. Let us look at the NP vowel system:

(4.7)

/i/		/u/	{I}	{U,R}
		/o/		{U,A,R}
/ae/	/a/		{ }	{A}

We assume that [E] plays no role in the system, contrary to Hall et al. Harmony is based on spreading of [A]. Since there is no /e/ the following SSC can be formulated:

(4.8) NOT: [I] & [A]

We can explain why /i/ is being skipped if we assume that the feature [A] on the one hand, and the features [I] and [U] on the other hand associate to

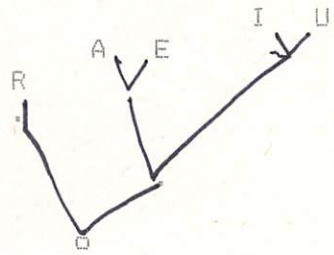
Because low vowels are opaque to

different class nodes. To be consistent we must assume that [A] and [E] associate to the same node. This move helps, since NP has no vowel /e/ and it can therefore be argued that the vowel /i/ lacks the class node to which [A] associates, [A] being the only feature which associates to this node in NP:

(4.9)

We end up then with the following hierarchical classification of vowel features:

(4.10)



Grouping together [A] and [E] on the one hand and [I] and [U] on the other is not unreasonable from a phonetic point of view. The former two both involve the supralaryngeal shape of the vocal tract. [I] and [U] on the other hand both involve constriction with the upper body of the tongue as the active articulator.

Footnote
This grouping also removes the grounds for objecting to the use of ATR to differentiate among two series of mid vowels.

STOP HERE

5. Problems

In this section I will consider problems which specifically relate to the use of single-valued features.

5.1. Opacity and disharmonic roots

The cases of opacity considered so far could be accounted for in terms of the interplay between ssc's and the prohibition on discontinous association. However, in certain cases vowels appear to be inaccessible with respect to a certain feature, without there being a SSC which prohibitis the configuaration which would arise.

The most typical case involves disharmonic roots, in which back vowels occur in the context of non-transparent front vowels without undergoing the influence of these. The non-transparent nature of the front vowels would be clear from the fact that they do spread to suffix vowels. A typical case in point in show in the following examples:

(5.1) buro - nak kosztum - nek

How do we prevent the harmonic feature from spreading to the back rounded

vowels in these cases? There are two ways to think of this problem. We might encode the inaccessibility of the back vowels, or the defective spreading capacity of the front vowels. In both cases we need an extra device.

Since we encounter cases in which particular morphemes appear to be immune with respect to F-spreading we must choose for the second option.

Some method must be found to indicate that segments are immune. Intuitively what we want to say is the following. A certain vowel, unspecified for [F], cannot be specified for [F], because its specification is COMPLETE with respect to that feature. In the paper on neutral vowels, Smith and I have suggested invoking the specification of segmental domains, and at present I have no better solution to offer. Hence the representation the disharmonic roots is:

(5.2)

[I]		[I]		
bur	o	koszt	u	m

5.2 Opacity and contrastiveness

We have seen that segments which lack a particular class node will be skipped by a spreading feature which associates to this node. Furthermore we have seen that class nodes are present if some feature which associates to this node is present.

It appears that this is only part of the truth. We will now show that class nodes to which no feature associates can be present, such that the segment in question will block spreading of any feature which associates to this node.

Let us first consider a case where segments which are distinctively not-F act as blockers, whereas those which are predictably not-F do not.

Barra dialect of Gaelic
Clements (1986) discusses the following case. In the Barra dialect of Gaelic epenthetic vowels are copies of the preceding vowel in general. Among the nonlabial consonants Barra has a plain/palatal contrast, expressed in terms of [+back]/[-back]. If in between the copee and the copy there is a nonlabial consonant (always a sonorant in epenthesis contexts) the copy takes the backness value of the intervening consonant. This pattern is straightforwardly explained if we assume that nonlabial consonants are specified for backness, whereas labials are not:

(5.3)

-B -B			-B +B			-B		
V	C	V	V	C	V	V	m	V
+B -B			+B +B			+B		
V	C	V	V	C	V	V	m	V

The question is how this pattern can be accounted for with SV-features:

(5.4)

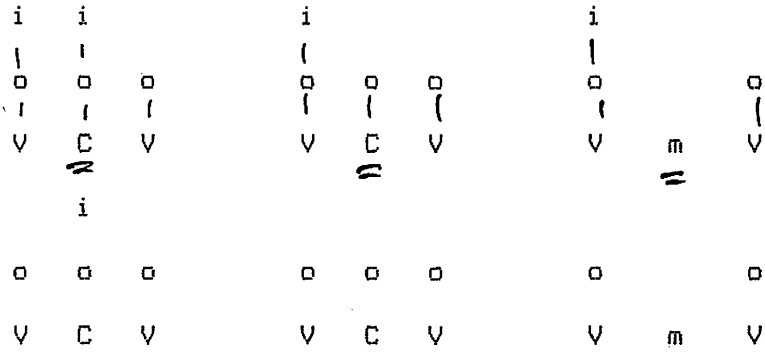
i i			i			i		
V	C	V	V	C	V	V	m	V
			----------					
	i					i		
V	C	V	V	C	V	V	m	V

The underlined case is the problematic one. Non-palatal consonants are opaque if and only if the intervening consonant has a contrastive value for backness. How do we represents this type of opaqueness and how can we distinguish between the behaviour of a consonant which is distinctively non-palatal and consonants which have no distinctive value for palatality.

Footnote
In Steriade's theory the distinction is clear cut. Distinctive non-palatals acquire [-back] by CR (if [+back] is the lexical value), whereas consonants which do not have a distinctive value for palatality get a value (whatever it is) by DR. The rule referred to above clearly is a C-rule, i.e. applies after C-values have been assigned and before D-values have been assigned. #

Let us assume then that it is possible for segments to have a particular node without there being a feature which is asociated to that node. And also that the presence of such EMPTY nodes is the result of rules, which create segmental structure which is not underlyingly present. To differentiate between segments which are contrastively NOT-F and segments which are predictably non-F we will assume that the creation of such empty nodes is such that only segments which the former are specified as such.

(5.5)



We cannot assume that empty, but contrastive nodes are there to begin with because there are other cases where segments which are contrastevely unspecified for F are nontheless skipped by F (e.g. [I] spreading in Leurbost, nasality spreading in Guarani, glotalic spreading in Spokane).

Of course the next point to investigate is the following: are there case where non-contrastive empty nodes act as blockers? It appears that Manchu is a case in point.

The system is as follows:

(5.6)

The so-called frontness harmony is, in line with Ard 1984, analyzed in terms of ATR (/a/ -> /@/ in the context of ATR vowels; those /i/ and /u/'s which fail to trigger this change are associated to [E] or simply unspecified for it).

Footnote
Interesting if roundness harmony involves the feature [U] /i/ is predicted to be opaque, but if RH involves [R] it should be skipped, lacking as it does, the LAB-node (i.e. there is no /y/).

To analyze this we would have to assume that at some point the full segmental structure is assigned, and that rules may apply after that. That rules apply after the specification of redundant information is something we have to assume

anyway for those cases where redundant "positive" information is spread. Think of cases where voicing harmony is triggered by sonorant consonants.

Footnote
Manchu then differs minimally from Khalkha Mongolian in that rounding harmony applies after the creation of redundant, but empty nodes. It it striking that next to Nez Perce we also find a minimal pair in which /i/ is not skipped by spreading [A], although in M. Korean too there is no /e/ in the vowel system. The system of M. Korean, is slightly different, having an extra row of back unrounded vowels:

/i/	/w/	/u/	{I}	{U}	{U,R}
/@/	/&/	/o/	{ }	{U,A}	{U,A,R}
/a/			{A}		

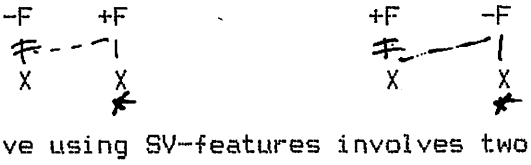
In this case /i/ is not skipped. Hence /i/ must have a [CAV]-node.

5.3. Symmetrical harmony rules

Finally, we will consider the problem of apparent symmetrical spreading of both "+" and "-".

Pasiego
In this case mid vowels become high in the context of a stressed high vowel whereas high vowels become mid in the context of a stressed mid vowel. Schematically then the following happens:

(5.7)



The alternative using SV-features involves two distinct operations: spreading and deletion.

(5.8)

In our terms then Pasiego height harmony must be stated as follows:

(5.9)

(* means "stressed")

Both rules are mirror-image rules.

Do we have to state two rules, as in (5.9)? The answer is No. The rule has to state which configuration meets the SD and what has to happen. Suppose we formulate the rule as follows:

(5.10)

[i] [i]

In the structure X ... X the nonstressed vowels must adjust in height such that it agrees with the stressed vowel

Given this formulation the two operations specified in (4.20) can be seen as supplied by universal grammar as the two ways in which (4.21) can be "served". It would be redundant to regard them as part of the rule.

Footnote
In this case a low vowel x----[A] may intervene between target and trigger. Given our analysis this cannot be considered a problem for two reasons. Firstly, the SD of the rule is locally met even if /a/ intervenes, since /a/ has no value on the [i]-tier. Secondly, spreading of [A] across the [A] which characterizes /a/ is possible in our approach.

EPILOGUE

In the preceding sections I hoped to have convinced you that interesting answers can be given to the questions we started out with. Undoubtedly the last section has also convinced you that other interesting questions remain or have answers which are not so satisfatory. Still, it is my belief that some progress has been made and that we are moving in the right direction.

Thank you.