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[high], [low] and [back] or [I], [A] and [U]?

Much recent work in the structure of the segment has utilised a system incorporating single-valued features, as opposed to the binary feature system of Chomsky & Halle (1968; henceforth SPE). Early proposals for single-valued features can be found in papers by Anderson & Jones (1974) and Sanders (1974), while more detailed proposals have been offered within various frameworks in recent years. In some of these, it appears that all features are considered to be single-valued – e.g. the models of dependency phonology (e.g. Anderson & Ewen 1987) and particle phonology (e.g. Schane 1984), and also work by Rennison (e.g. 1987); in others only some features are single-valued (Steriade 1987), or the same feature may be single-valued in one phonological system and binary in another (Goldsmith 1985); while in the model of charm phonology proposed by Kaye and others (e.g. Kaye et al. 1985), single-valued elements are realised as binary features, although the latter play no role in phonological processes.

Our concern here is not with the issue of single-valued features as such, however. There is another respect in which the models just mentioned typically differ from the standard SPE system of representation, at least with respect to the vowel space. This involves not the nature of the features themselves, but the way in which they divide up the vowel space. The SPE features treat the vowel space as rectangular, as in (1):

(1)		[−back]	[+back]	
	[+high]	/i/	/u/	[−low]
	[−high]	/e/	/o/	[−low]
	[−high]	/æ/	/ɑ/	[+low]

(with rounding being superimposed). A typical single-valued system, however, is essentially triangular, and looks something like (2):

(2)	[front]	/i/		/u/	[round]
			/a/		
			[low]		

with mid vowels represented as containing the feature [low] and one of the others, as in (3):

(3) [front, low] /e/ /o/ [round, low]

(The particular feature-labels given here are chosen purely for illustration.)

We should notice first of all that there is no necessary correlation between single-valued features and a triangular division of the vowel space. Indeed, Sanders' original proposals were in terms of a rectangular model, and at least one approach, that of Lass (1984a), utilises a rectangular variant of the model of dependency phonology:

(4)	[front]	[velar]
	/i/	/u/
[low]	/æ/	/ɑ/

(with, as in most other single-valued systems, mid vowels being combinations of the lowness feature and one other, while, as in the SPE system, a rounding feature is superimposed).

Triangular binary systems have also been proposed – thus Rennison (1987) characterises the ATR vowels of Koromfe as in (5):

(5)	[+I]		[–I]
[–A]	/i/		/u/
[+A]	/e/		/o/
[+A]		/ɑ/	

However, things become rather more problematical here, as /ɑ/ has to be characterised as [–I]. Rennison provides a definition of his features in terms of each feature exerting a 'pull' on the tongue body towards the relevant position, and further assumes that the minus value for any feature is not specified. It is difficult to see this representation as much more than a notational variant of a single-valued system.

Interestingly, though, there has been little explicit argumentation for the adoption of a triangular system of representation. In this paper we want to consider some of the issues involved, and we shall present a proposal for one apparent problem area for single-valued features, the representation of the notion of two vowels having the same height.

We can distinguish two major respects in which rectangular and triangular systems typically differ. The first of these involves the characterisation of the aperture parameter. While SPE uses the binary features [high] and [low], triangular systems generally utilise a single feature [low] (with various definitions). Low vowels and mid vowels contain the lowness feature (or are [+low], in a binary approach); high vowels do not. Mid vowels are distinguished from low vowels by the fact that the lowness feature combines with one of what are often referred to as the tonality features, often frontness and roundness. This brings us to the second point of difference: whereas SPE-type systems select back as the positive pole of the tonality feature characterising the front–back dimension, triangular models have a feature [front], so that front vowels are positively specified. Back vowels lack a specification on this dimension, but typically contain a roundness feature.

There are fairly obvious reasons, both phonological and phonetic, for preferring a triangular system over a rectangular one. In terms of phonological systems, for example those in the survey in Maddieson (1984), the overwhelming majority are triangular in shape (in spite of the objections of Lass 1984b); i.e., in general, there are more oppositions amongst high vowels than amongst low vowels, so that languages having two low vowels differing only in the front–back dimension, and not in length, are very rare. This obviously has a phonetic basis, which is primarily acoustic: while the articulatory vowel space can be interpreted as being rectangular in form, the acoustic vowel space seems to be triangular, with what are sometimes referred to as the quantal vowels [i], [u] and [ɑ] delimiting this space.

We do not want to pursue this in any detail, however. What we are interested in here is a problem that arises in single-valued approaches with three features glossed articulatorily as front, round and low. This is the characterisation of the fact that two vowels have the same height. In other words, how, for example, do we characterise /i/ and /u/ in a system as forming a natural class?

In an SPE-type system, of course, these vowels are simply [+high]. But in the single-valued triangular systems we have been looking at, the best we can do seems to be a negative definition of the sort proposed in dependency phonology: high vowels are those not containing the feature [low]. This can be formulated in various ways, none of which seems very satisfactory; (6) might be a possibility:

(6) {-a}

It is clear that two vowels having the same height can in fact form a class to which we want to be able to refer, and we will propose a solution to this problem on the basis of one recent treatment of vowel cooccurrence restrictions, that of Mester (1986). This approach is relevant to our discussion not only because it deals with the relationship of the height and backness features, but also because, as we shall see, he introduces the notion of dependency, in this case with respect to the ordering of tiers.

Mester notices that there are languages in which cooccurrence restrictions between height and backness can result in two different situations. In one case, (7a), backness (or perhaps rounding) depends on height; in the other, (7b), the reverse holds:

(7) a. Ngbaka: vowels of the same height must have the same value for backness.

b. Ainu: vowels with the same backness value must have the same height.

This means that the situation in (8a) holds for Ngbaka, and that in (8b) for Ainu:

(8) a. Ngbaka b. Ainu

a. Ngbaka		b. Ainu	
uCu	*oCe	uCu	oCe
*uCi	oCi	uCi	oCi
uCo	iCi	*uCo	iCi
uCe	iCe	uCe	*iCe
oCo	eCe	oCo	eCe

Notice in passing that the very existence of the restrictions on cooccurrence given in (7) and (8) provide further support for a triangular approach: the low vowel in both systems fails to take part in the process.

Mester's treatment of the restrictions in (7) involves the ordering of tiers in a dependency relation: in the (a) cases, the backness tier is dependent on the height tier; in the (b) cases, the relationship is reversed:

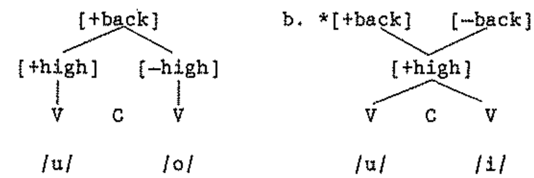
```
(9) a. [back]         b. [high]
         |                 |
       [high]            [back]
         |                 |
         °                 °        class node
```

The Obligatory Contour Principle (OCP), together with the ordering of the two tiers, excludes the disallowed combination of vowels in the two cases, by a principle which is basically that in (10):

(10) If the OCP applies to a head it also applies to its dependent.

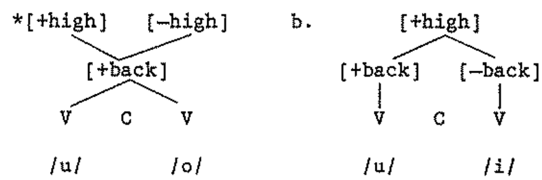
Thus, if the representations on the head tier are identical, those on the dependent tier must be the same as well, so that in (11) the (a) form in Ngbaka would be acceptable, but the (b) form would not:

(11) a. b.



The reverse tier ordering holds for Ainu, however:

(12) a. b.



Our treatment of this area in a single-valued triangular system makes crucial use of a proposal first presented by van der Hulst (1988). This involves associating with each of the features |i|, |u| and |a| a dual interpretation, depending on whether the features functions as a <u>head</u> (or <u>governor</u>) feature or as an <u>operator</u> (or <u>dependent</u>) feature. These interpretations are given in (13):

(13)

Interpretation of:	|i|	|u|	|a|
Head/governor:	Palatal constriction	Velar constriction	Pharyngeal constriction
Operator/dependent:	Advanced tongue root	Rounding	Openness

Thus, the |u| feature characterises <u>both</u> backness <u>and</u> rounding, but the status of each is different, while the |i| feature gives us both frontness and ATR. We will not go into the phonetic motivation for these proposals here, but we note in passing that there is a sound articulatory basis for allowing the various pairs of properties to be related in some way in our phonological system.

As is not unusual, we assume that not all features need be 'active' in a system. In other words, a feature may be simply not phonologically relevant. More particularly, if a language does not make reference to the class of back vowels, then the head feature |U| is not active in that language's phonological system. In such systems, then, the feature cannot govern. Now we might want to suggest that, if a particular head feature is not active, then this will have consequences for the interpretation of those features which <u>are</u> active. More specifically, if |U| is not active, then what we would like to be able to suggest is that the presence of |I| characterises the set of non-low vowels, as in (14):

(14)

I	IA	A	IA	I
			u	u
/i/	/e/	/ɑ/	/o/	/u/

(From now on we use capitals to denote head features, and lower case for operator features.) But this clearly raises problems: the head feature |I| has been defined as involving palatal constriction, whereas back vowels do not have this property.

To get round this difficulty, we want to propose that there is a formal relation between the |I| and the |U| features, which neither of them shares with the |A| feature. This relationship has of course long been recognised in work on single-valued features: while the tonality features characterising frontness and roundness combine freely in such theories with the lowness feature, combinations of |I| and |U| are comparatively rare: in other words, while languages may have a number of mid vowels, it is extremely uncommon to find more than one front rounded vowel at any particular height.

What we are suggesting is that the |I| and |U| features are sub-features, or further specifications, of a superordinate feature which we might gloss as <u>tongue-body constriction</u>, which we represent as in (15):

(15) |Y|

Tongue-body constriction

|Y|, then, is a superordinate term to the head features |I| and |U|, as in (16):

(16)

|Y| Tongue-body constriction

|I| Palatal constriction — |i| Advanced tongue root

|U| Velar constriction — |u| Rounding

|A| Pharyngeal constriction — |a| Openness

We shall not pursue here the exact formal nature of the relation between the tongue-body feature |Y| and the palatal and velar features |I| and |U|. It is clear that there are links here with the notion of a dorsal node or tier, with the feature [lingual] proposed by Lass, and various other approaches. However, we suspect that |I| and |U| should be treated not as independent features, but as **values** of the feature |Y|. This would mean treating |Y| not as a single-valued feature, but as a multivalued feature, specifically a binary equipollent feature, in Trubetzkoy's terms. Crucially, it is not a privative +/– <u>SPE</u>-type feature. If |I| and |U| are values, rather than features, this explains why they cannot occur together as head features in the representation of a single segment. (This does not exclude the occurrence of one as a head feature and the other as an operator feature, as we will see shortly).

Adopting (16) means that the oppositions in a vowel system can potentially be of two types, as in (17):

```
(17) a. Y          b. I———U
        |               |
        A               A
```

In systems like (17b), in which |U| is active, i.e. in which backness <u>does</u> play a phonological role, e.g. one with front rounded vowels, vowels will be specified as having a value for the feature |Y|, i.e. either |I| or |U|. (Of course, the feature |Y| is itself 'externally' single-valued: it need not be present at all. This is equivalent to the claim within models of feature geometry (e.g. Clements 1985; Sagey 1986) that a segment which is not specified for some node may not be specified for any of the features which that node dominates - see Archangeli (1988) for discussion.)

In an approach like this, a system such as (17b) might be represented as in (18):

```
(18)  I      I      A      U      U      I
             |             |             |
             a             a             u

     /i/    /e/    /ɑ/    /o/    /u/    /y/
```

which looks very traditional. In a system which does not need to make a distinction between front and back, however, the two values for the feature |Y| are not distinct, and so we require only |Y| in the representation, as in (19):

```
(19)  Y      YA     A      YA     Y
                           |      |
                           u      u

     /i/    /e/    /ɑ/    /o/    /u/
```

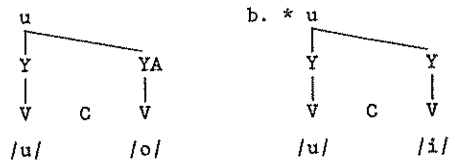
In the system in (19) the characterisation of the set of high vowels or the set of mid vowels is now straightforward: high vowels are those containing |Y| alone as head feature, mid vowels those with |Y| in combination, and non-low vowels those with at least |Y|.

We return now to the phenomena discussed by Mester. We will show first that a translation of Mester's analysis into the type of approach outlined here goes some way to providing a satisfactory account of the situation in Ngbaka and Ainu. However, we will then conclude that we need to provide further constraints on the model in (16). Consider first of all the Ngbaka system given by Mester as (20a):

```
(20) a. i     u        b. Y        Y u
        e     o           Y A i    Y A u i
        ɛ     ɔ           Y A      Y A u
           a                   A
```

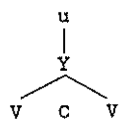
As we have seen, in Ngbaka the backness tier was dependent on the height tier in Mester's approach. This situation can be characterised in our single-valued model by assuming that |I| is not active in the Ngbaka system. This means that the representations in (20b) are appropriate (where the distinction between the two sets of mid vowels is characterised as an ATR opposition, i.e. by the presence or absence of |i| as an operator feature). In turn, the difference between the acceptable sequence of two back vowels of different heights and the unacceptable sequence of two high vowels differing in backness can be given as (21):

(21) a.



Once again, the OCP excludes (b) as a possibility. However, unlike the representation given by Mester as (11b), which is excluded by the extension to the OCP given as (10), we have here no need to invoke an extra external principle or stipulation of this sort. The fact that |u| is a single-valued operator feature means that (21b) can only be interpreted as (22):

(22) *



Whatever this can represent, it is clearly not a sequence of /u/ + /i/. (11b), on the other hand, is unacceptable only on theoretical grounds: it is certainly interpretable as the sequence in question.

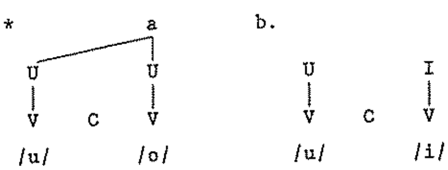
Notice that |A| in the system in (19) functions as a head feature. We suggest that the nature of the combination of |A| with other features is dependent on the type of system in which it occurs. If the system does not have |U| as an active value, as in (17b), so that we find |Y| in the representation, then |A| occurs as a head feature when in combination with |Y|, as in (20b). However, if the opposition between |I| and |U| is active, combinations of these features will be with |a| as an operator feature. Basically, then, only features on the same hierarchical level may combine.

The situation in Ainu can be characterised as in (23):

(23) a.	i		u	b. I		U
	e		o	I a		U a
		a			A	

Notice that we characterise the mid vowels in Ainu as having |a| as an operator feature. This allows us to represent the relevant sequences as in (24):

(24) a. *



Here |a| is an operator feature, and so the OCP blocks (23a). However, it might well be claimed that the phonetic evidence for characterising the mid vowels in Ainu with |a| and those in Ngbaka with |A| is hard to find – indeed, that the use of the distinction is little more than diacritic.

We suggest that this problem can be overcome by further enriching the degree of hierarchical structure available in the representation of segments. Let us first assume that any segment can have only a <u>single</u> head feature, so that representations such as those for the Ngbaka mid vowels in (20b) are excluded. Such an interpretation of headship accords well with traditional views of phonological structure – both segmental and suprasegmental – within models such as dependency phonology (e.g. Anderson & Ewen 1987). Thus, instead of (20), we might have the representations in (25):

```
(25) a. i       u          b. Y i        Y i u
        e       o             Y a i      Y a i u
        ɛ       ɔ             Y a        Y a u
            a                       A
```

Notice that /i/ and /u/ are ATR vowels in Ngbaka, and hence contain the operator feature |i|. In addition, we assume that the operator features are hierarchically ordered, as shown in (26), the equivalent of (21):

```
(26) a.            u          b. *
                   |
         u         i              u
         |         |              |
         i         a              i          i
         |         |              |          |
         Y         Y              Y          Y
         |         |              |          |
         V    C    V              V    C     V

        /u/       /o/            /u/        /i/
```

Here the operator features are ordered, such that |a| governs |i| and |i| governs |u|. (It may well be that such ordering is parameterised – we do not consider this question any further here.)

We assume that the adoption of a hierarchy of operator features as in (26) leads to a somewhat different interpretation of the restrictions on the OCP than those proposed by Mester in (10). Specifically we suggest that the following principle holds: the application of the OCP at some hierarchical level n̲ presupposes identity of all features on levels directly or indirectly governing n̲. Thus, in (26a), the presence of the operator feature |a| governing |i| for /o/ prevents the OCP from collapsing the two structures. In (26b), on the other hand, the difference between the two vowels consists merely in the presence of the governed feature |u| for the vowel /u/, and so the OCP must apply in Ngbaka, thus rendering the sequence in (26b) ungrammatical. If such a principle can be maintained, it shows interesting parallels with the 'Parasitic Principle' proposed by van der Hulst & Smith (1987: 87).

Our discussion has shown two things. Firstly, by assuming that vocalic features are organised hierarchically, we can make reference to the notion of vowels having the same height without having to abandon the triangular framework. Secondly, we have shown that Mester's proposal to define dependency relations over pairs of vocalic features, an ad hoc move in Mester's model, is a notion which is fundamental to various single-valued approaches to segmental structure, and can thus be incorporated in these models in a structured fashion.

References

ANDERSON, J.M. & C.J. EWEN
1987 Principles of dependency phonology, Cambridge, Cambridge University Press

ANDERSON, J.M. & C. JONES
1974 Three theses concerning phonological representations, in Journal of Linguistics 10, 1-26

ARCHANGELI, D.
1988 Aspects of underspecification theory, to appear in Phonology 5

CHOMSKY, N. & M. HALLE
1968 The sound pattern of English, New York, Harper & Row

CLEMENTS, G.N.
1985 The geometry of phonological features, in Phonology Yearbook 2, 225-252

GOLDSMITH, J.A.
1985 Vowel harmony in Khalkha Mongolian, Yaka, Finnish and Hungarian, in Phonology Yearbook 2, 253-275

HULST, H.G. van der
1988 The geometry of vocalic features, to appear in the Proceedings of the Annual Meeting of the North Eastern Linguistics Society, Toronto, 1987

HULST, H.G. van der & N.S.H. SMITH
1987 Vowel harmony in Khalkha and Buriat (East Mongolian), in F. Beukema & P. Coopmans (eds) Linguistics in the Netherlands 1987, Dordrecht, Foris, 81-89

KAYE, J., J. LOWENSTAMM & J.-R. VERGNAUD
1985 The internal structure of phonological elements: a theory of charm and government, in Phonology Yearbook 2, 305-328

LASS, R.
1984a Phonology, Cambridge, Cambridge University Press
1984b Vowel system universals and typology: prologue to theory, in Phonology Yearbook 1, 75-111

MADDIESON, I.
1984 Patterns of sounds, Cambridge, Cambridge University Press

MESTER, R.-A.
1986 Studies in tier structure, PhD dissertation, University of Massachusetts, Amherst

RENNISON, J.R.
1987 On the vowel harmonies of Koromfe (Burkina Faso, West Africa), in W.U. Dressler, H.C. Luschützky, O.E. Pfeiffer & J.R. Rennison (eds) Phonologica 1984, Cambridge, Cambridge University Press, 239-246

SAGEY, E.
1986 The representation of features and relations in autosegmental phonology, PhD dissertation, MIT.

SANDERS, G.A.
1974 The simplex-feature hypothesis, in Glossa 8, 141-192

SCHANE, S.A.
1984 The fundamentals of particle phonology, in Phonology Yearbook 1, 129-155

STERIADE, D.
1987 Redundant values, ms