2
Features

2.1 The nature of phonological features

In Chapter 1 we established that the atoms of phonological representation must be smaller than the segments expressed in the notational system of, for example, the IPA, and that these atoms are appropriately modelled by units commonly referred to as phonological features. Each phonological feature is defined in terms of some phonetic property, so that any phonological feature system makes a claim as to the phonetic properties which can function in the phonological processes of languages. The value associated with a feature for a particular segment shows that that segment either does or does not bear the phonetic property in question. For example, if we assign a segment the feature-values [+low, –round], we are claiming that it belongs to the **class** of [+low] segments, but not to the class of [+round] segments. Although this may seem trivial, we shall show later in this section that the latter claim is not as straightforward as it may appear. In particular, the corollary of the claim, i.e. that something which does not belong to the class of [+round] segments therefore belongs to the class of [–round] segments, is controversial, and we shall return to this below. However, irrespective of this issue, the tacit assumption we have been making is that there is always a binary choice involved: segments either belong to the set characterised by '+' or the set characterised by '–'. On this assumption, segments never have *more* than two degrees of a particular property, at least from a phonological viewpoint.[1]

This **binarity** claim constitutes an empirical hypothesis, which is not immediately supported by phonetic observations, or indeed by certain phonological analyses. Consider, for example, the phenomenon of nasalisation. It is indisputable that, from a phonetic point of view, we can establish the existence of various degrees of nasalisation, and this might lead us to wonder

[1] See, however, our discussion of vowel height in §1.3.3; we return to this below.

whether it is necessary for phonological classification to be strictly binary. Indeed, various phonologists have argued that certain phonological oppositions are clearly **multivalued**, rather than binary, and that this should be reflected by allowing *phonological* features to have more than two values. For example, Ladefoged (1971: 35) suggests that the language Chinantec, spoken in Mexico, may have two contrastive degrees of nasalisation, as in (1) (data from the Palantla dialect of Chinantec; Merrifield 1963):[2]

(1) a. *non-nasalised*

hɑ	'so, such'
dzɑ e dzɑ si	'he goes to teach reading'

b. *lightly nasalised*

hɑ̃	'(he) spreads open'
dzɑ ẽ dzɑ hɑ	'he goes to count animals'

c. *heavily nasalised*

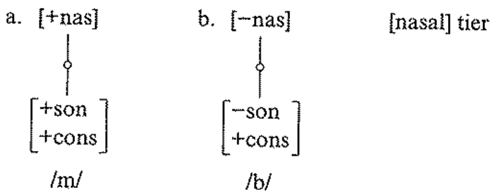
hɑ̰̃	'foam, froth'
dzɑ ḛ̃ dzɑ hɑ	'he goes to chase animals'

It might appear from (1) that a feature with at least three values is required to characterise this state of affairs. That is, we might characterise the nasality by means of a multivalued scalar feature, with the values [0 nasal], [1 nasal] and [2 nasal], in much the same way as suggested for vowel height in (25) of Chapter 1. Nevertheless, many phonologists have adopted the strongest possible version of the binarity hypothesis, i.e. that *all* phonological classification is binary. Proponents of this view, then, analyse apparently multivalued features in terms of two or more binary features. Such a strategy is apparent in the analysis of the vowel-height dimension in (21) in Chapter 1, in which what appeared at first sight to be a single multivalued parameter of vowel height was analysed in terms of the two binary features [high] and [low].

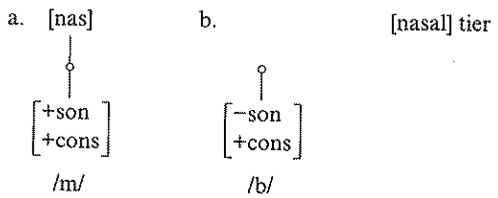
We do not at this point investigate the issue of whether we should allow for multivalued features in phonological descriptions. Rather, we restrict our discussion to the nature and representation of those oppositions which appear to involve no more than two members.

At first sight, the most natural way of representing the binarity hypothesis is to use the binary features which we introduced in Chapter 1, such as [±nasal], [±coronal], etc. In terms of the type of feature geometry which we introduced in §1.3.5, this approach is characterised by (2), which represents the difference between a nasal and a non-nasal sound, say English /m/ and /b/:

[2] We ignore tones here.

(2)


(Here and in what follows we associate the nasal feature with a node which denotes all other tiers in the segmental representation not relevant for the present discussion, but retain the major class tier.) However, there are other ways in which we might indicate whether a segment either has or does not have a particular property. Alongside specifications consisting of a feature-value and name, such as [+nasal], we might also make use of the contrast in (3):

(3)


Here /m/ is characterised by making the feature [nasal] part of its representation, while /b/ has all the properties that /m/ has, except that it *lacks* the feature [nasal], i.e. it is a non-nasal sound. Thus we make no use of the *values* '+' and '−'; rather, /m/ is seen as having a property which /b/ lacks entirely. These two ways of representing a binary opposition may appear to be more or less equivalent. However, they embody two rather different empirical claims, as we will now show.

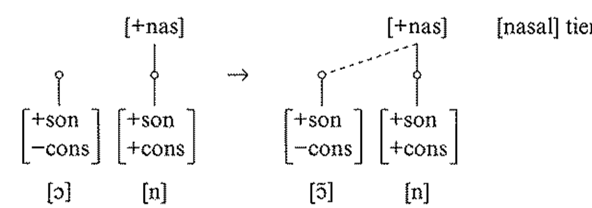
As we saw in §1.2, sets of segments which recurrently participate in phonological processes are referred to as natural classes. We claimed furthermore that the fact that a particular set of segments forms a natural class is in turn attributable to some shared phonetic property such as nasality, roundness or degree of sonorancy. The shared phonetic property is characterised in our system of phonological representation by a phonological feature, so that in the approach adopted in Chapter 1 all the segments forming a natural class bear the same value for a particular feature. Thus /u o ɔ y w/ in a particular language may take part in a phonological process by virtue of the fact that they form the natural class characterised within the system of phonological representation as [+round], as may /p t k b d g f θ s v ð z/, by virtue of their all being [−sonorant].

On the assumption that any binary feature can have both the values '+' and '−', it appears that the set of segments sharing either value for a particular

feature should form a natural class. In other words, it should not matter whether a set of segments is characterised as [+F] or [−F] (where [F] is any feature); in either case, the set can take part in phonological processes. This claim is inherent in (2), the 'traditional' binary approach, which suggests that we can find phonological processes which make reference not only to the set of [+nasal] segments, but also to the set of [−nasal] segments. (3), however, makes a rather different claim, i.e. that only the nasal segments can have this status – there is no means of referring to the set of non-nasal sounds, which have no unique identifying property in (3); rather, the difference between nasal and non-nasal sounds is that the latter simply lack a property which the former possess.

It is clear, then, that the kind of evidence which we must look for in choosing between (2) and (3) consists in showing whether the set of non-nasal segments ever functions as a natural class in languages. If we do not discover such a case, we have, on the assumption that this state of affairs is not accidental but represents a 'real' phonological generalisation, immediately uncovered evidence for rejecting the binarity hypothesis in its traditional form, and, all other things being equal, for introducing segmental representations such as that in (3). The reverse also holds, of course: if the class of non-nasal sounds *does* play a role in the phonology of some language, then representations like those in (2) seem more appropriate.[3]

We have already seen that the set of nasal segments in a language constitutes a natural class. Recall the various examples discussed in §1.2, where all and only the nasal segments agree in place of articulation with a following consonant. Consider too the very common processes whereby nasal consonants spread their nasality to preceding vowels, to give allophonically nasalised vowels, as in English *plank* /plæŋk/ [pl̥æ̃ŋk] (cf. (74) in Chapter 1), or, in some languages, phonemically nasalised vowels, as in French *bon* /bɔ̃/ (with subsequent deletion of the nasal consonant):

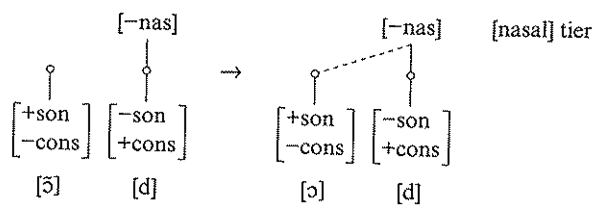
(4)


However, examples in which non-nasal sounds function as a natural class are, as far as we know, not attested. We do not find processes affecting, for

[3] In fact, evidence allowing us to reject the traditional binarity hypothesis is logically not available – in formal terms, it is a non-falsifiable hypothesis.

example, the class of non-nasal coronals (say /t d s z θ ð l r/) in a language, as opposed to the class of nasal coronals (/n/). For example, rules similar to (4), but with [−nasal] as the spreading node, as in (5), are simply unrecorded:

(5)



(5), which would change [ɔ̃d] into [ɔd] by spreading of [−nasal], is apparently an impossible rule.[4] This might of course be no more than an accidental gap in our knowledge of phonological processes, but, on the other hand, it might reflect a basic property of the phonological system, i.e. that nasality and the lack of nasality are not equivalent. If this is the case – and there seems little doubt that it is – then a theory of phonological representation which allows us to address either value equally easily seems to be excessively powerful. In general, our aim should be to restrict any part of our phonological theory to describe or generate states of affairs which are actually found in languages, and to prevent it from being able to describe things which are not found. Furthermore, the theory should make it more difficult to describe 'less natural' or 'unnatural' states of affairs. In other words, the generative capacity of our theory should be as limited as possible, always provided that we can adequately describe what *does* take place in the phonologies of the languages of the world.

In this case, then, it looks as if the lack of nasality is not a positive property of a segment, and thus plays no role in the characterisation of sounds, classes and processes. This in turn means that (3) apparently expresses this state of affairs more appropriately than (2), which suggests that [−nasal] is an 'addressable' value, and thus, inappropriately, allows the formulation of rules like (5). A system based on (3), however, does not have anything corresponding to the value [−nasal], and so cannot allow a rule to have the effect of (5); it is therefore to be preferred in this respect. The only way of excluding the possibility of the spreading of the lack of nasality in a system with [+nasal] *and* [−nasal], such as (2), would be to exclude reference to [−nasal] by incorporating some kind of explicit statement to the effect that this value

[4] We are not denying here that there are constraints in languages whereby a nasal vowel must be followed by a nasal consonant, while a non-nasal vowel must be followed by a non-nasal consonant. However, these do not result from spreading as such, but rather from general constraints on the well-formedness of particular sequences of vowel + consonant.

cannot function as a natural class – surely an undesirable and arbitrary complication.

However, the apparently asymmetric behaviour of [nasal] does not necessarily have consequences for all other features. Consider [sonorant], for example. We saw in §1.3.1 that there are processes affecting the class of [+sonorant] consonants, but also processes affecting the class of [−sonorant] segments. Thus the natural class of nasals and liquids can be referred to in phonological processes as [+sonorant, +consonantal], and, as we saw in (13) in Chapter 1, [−sonorant] is the feature-value which characterises the class of segments typically involved in final devoicing processes, i.e. stops and fricatives. Clearly, then, the difference between the sets of sonorant and non-sonorant segments is of a different phonological type from that between the sets of nasal and non-nasal segments: *both* [+sonorant] *and* [−sonorant] characterise natural classes.

The notion that features may be of different 'formal types' is obscured in the *SPE* binary approach, and indeed in the Jakobsonian precursor to *SPE*.[5] Nevertheless, it has a long tradition, although the original formulation of this idea was couched in a rather different theoretical framework, which did not incorporate the notion of feature in the form we have been discussing in this book. Trubetzkoy (1939) draws a distinction between two types of binary phonological opposition: **privative** and **equipollent**, in addition to **multivalued** oppositions of the type mentioned in §§1.3.3 and 2.1.[6] In the interpretation we have just given, nasality is an example of a privative opposition, i.e. one involving two classes which are characterised by the presence vs absence of a particular property, or 'mark' (*Merkmal* in Trubetzkoy's terms). As well as nasality, Trubetzkoy characterises contrasts involving rounding and voicing as examples of privative oppositions. In equipollent oppositions, on the other hand, two classes of sounds differ in that *both* classes have some property which the other lacks. The relation between the members of an equipollent opposition is one of 'logical equivalence' (Lass 1984a: 46). In feature theory, this notion has acquired a rather more specific interpretation, as we have seen with reference to the feature [sonorant]. It is used to characterise those binary features of which both values are available in the statement of phonological processes. Thus, for a feature [F], if both [+F] and [−F] form natural classes, the feature [F] is equipollent. In such cases, a representation like (6) (which appears inappropriate for [nasal]; cf. (2)) seems to reflect the equipollent character of the opposition:

[5] See Jakobson *et al.* (1951) and Jakobson and Halle (1956).
[6] For a discussion of these and related notions, see Lass (1984a: §3.2).

(6) a. [+son] b. [−son] [sonorant] tier

[+cons] [+cons]

/r/ /z/

Similarly, if it is the case that vowel frontness and backness, for example, are 'logically equivalent', in that phonological processes can make appeal to either property,[7] the claim would be that there is a single feature, say [±back], which is equipollent: [+back] and [−back] have equivalent phonological status.

In what follows, we will restrict the term **binary** to equipollent features like [sonorant] in (6), with both a '+' and a '−' value, while we will refer to features characterising privative oppositions, as in (3), as **single-valued** features.[8] Single-valued features, then, do not have '+' or '−' values, but are simply present or absent.

2.1.1 Feature geometry and the nature of features

In drawing a formal distinction between the different types of features in such a rigorous way, we are going somewhat further than proponents of various of the geometrical models introduced in §1.3.5, where the distinction between the various types of opposition – equipollent, privative and multivalued – is utilised, but often not made formally explicit. Consider again representations like (75) in Chapter 1, a possible feature geometry for English *cab*. We drew a distinction between class nodes, i.e. labels for groups of features, on the one hand, and content nodes, i.e. nodes labelled by individual features such as [back]. We also saw that in a form like *camber*, the nasal had no independent place of articulation; rather, its place of articulation was determined by autosegmental spreading from the following stop. In other words, as we showed in (76) and (77) in Chapter 1, the nasal simply lacked a place node of its own (and hence all the other nodes dominated by it). In terms of the distinction we have just introduced, then, it seems that the place node, like other class nodes, is a single-valued 'feature'.

As we have now seen, some features, and hence content nodes, are also single-valued, in that they express privative oppositions. However, the relations between features are somewhat complex in feature geometry, and we consider here some of the formal aspects of the representation of place of articulation, in terms of the 'articulator theory' introduced in §1.3.4. It will be

[7] Such a claim is inherent in *SPE*, which treats neither [+back] nor [−back] as 'marked'; see the discussion of markedness and underspecification in §2.2.

[8] The terms 'unary' and 'monovalent' are also used.

recalled that, following McCarthy (1988), we distinguished a number of major places of articulation, characterised by the features [labial], [coronal], [dorsal] and [radical] (for the sake of the present discussion, we shall ignore radical consonants, i.e. those produced with the root of the tongue as the primary articulator). In feature geometry, each of the nodes characterising these features is dominated by the articulatory, or Place, node, as in (7):

(7) Place

[labial] [coronal] [dorsal]

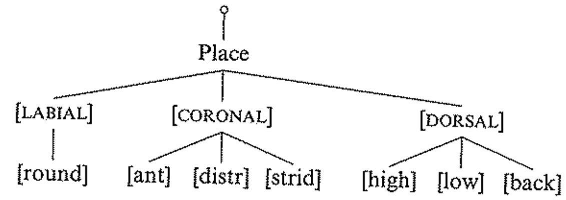
It is clear that a consonant is either [labial], [coronal] or [dorsal]: consonants do not usually have more than one place of articulation.[9] Thus the relationship between the three primary nodes we have introduced in (7) is one of mutual exclusivity. Each of the features is single-valued: it is either present or absent. Equally, though, we can say that the class node Place is multivalued, with three possible values ([labial], [coronal] and [dorsal]). Notice that because the three values are mutually exclusive, they are in a **disjunctive** relationship: only one value of Place can be chosen.

Unlike Place, which is a class node, [labial], [coronal] and [dorsal] are clearly content nodes; to say that something is 'labial' identifies its place of articulation, for example. But these nodes may also dominate other nodes in feature geometry. Recall from §1.3.4 that one of the advantages claimed for a model incorporating [labial], [coronal] and [dorsal] was that a feature such as [anterior], defined as involving a stricture in front of the postalveolar region, could be characterised as being only relevant to segments which are [coronal]. That is, if a consonant is not [coronal], then the question of whether it is [+anterior] or [−anterior] simply does not arise. Similarly, if a consonant is not [dorsal], its values for [high], [low] and [back] (features characterising the position of the body of the tongue) are irrelevant; if the body of the tongue is not involved in the production of a consonant, then its position does not need to be stated. Much the same holds for [strident] and [distributed], restricted to [coronal] consonants, and [round], restricted to labials.

The notion of certain features only being relevant if other features are present is represented in feature geometry as in (8):

[9] This is not to say that cases of double articulation (/k͡p, k͡t/) and secondary articulation (/ɫ, pʲ/) do not occur. These are treated in feature geometry by assuming that a single consonant has two distinct place specifications.

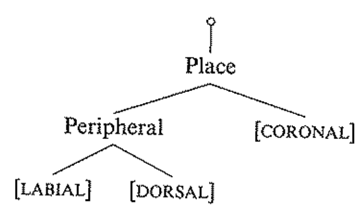
(8)



Here [round] is said to be a **dependent** of [LABIAL], while [anterior], [distributed] and [strident] are dependents of [CORONAL], and so on. Thus the occurrence of a specification for [anterior], say, is dependent on the presence of [CORONAL]. Notice that we now represent the features [LABIAL], [CORONAL] and [DORSAL] in a different way from [round], [anterior], etc. This is to show that they are single-valued content nodes which are intermediate between the class node Place and the 'terminal' content nodes, which are binary. The intermediate nodes, being single-valued, may be present or absent. The binary terminal nodes, however, must bear either the value '+' or '–' if they are 'relevant', i.e. if and only if the intermediate feature on which they are dependent is also present.

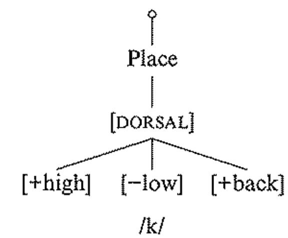
As Yip (1989: 350) points out, the evidence for the claim that nodes like [LABIAL], [CORONAL] and [DORSAL] appear to be single-valued lies in the natural class behaviour of the various places of articulation: [–coronal] does not occur. In other words, she claims, we do not find phonological processes affecting the set of non-coronals (e.g. /p k q/). If [–coronal], for example, is not a candidate for the definition of a natural class, then we are dealing here with a privative opposition, and thus a single-valued feature. However, the set of labials, velars and uvulars may form a natural class. This, however, is not by virtue of the fact that they do not involve a tongue-blade constriction, but perhaps for acoustic reasons. This leads Avery and Rice (1989: 195) to group [LABIAL] and [DORSAL] together under a Peripheral or Grave node, as in (9):

(9)



Like the class nodes, then, the intermediate content nodes we have established are single-valued, in the sense that they can be present or absent. However, the relationship between the class node Place and its dependents [LABIAL], [CORONAL] and [DORSAL] in (8) is different from that between, say, the intermediate node [DORSAL] and its dependent terminal features [high], [low] and [back]. We saw that the relationship between the various intermediate features was a disjunctive one: only one feature could be chosen for any one segment. However, the features dominated by [DORSAL] are in a **conjunctive** relationship: dorsal consonants will bear specifications for *each* of the features [high], [low] and [back]. Thus the representation for English /k/ might be:[10]

(10)



Clearly, then, we have arrived at an analysis in which the [LABIAL], [CORONAL] and [DORSAL] nodes are intermediate, in type as well as position, between 'class nodes' and 'terminal content nodes'. They are single-valued nodes, and may be entirely absent. If they are absent, then any of the content nodes which they dominate will also be absent, in exactly the same way as, if the Place node is absent, none of the nodes [LABIAL], [CORONAL] or [DORSAL] will be present (as in the assimilation examples we have already discussed). However, they have content, unlike class nodes.[11]

2.2 The representation of feature asymmetry

We suggested above that the most appropriate way of handling asymmetry of the type evidenced by privative oppositions involving nasality is to incorporate single-valued features into our analysis, thus abandoning the strict binarity hypothesis. In the previous subsection we saw that feature geometry, although typically acknowledging that both single-valued and binary nodes are required, fails to make a clear formal distinction between the various types of phonological oppositions we have encountered. Later in this chapter, we shall examine a system which makes use of single-valued features, but,

[10] Notice that (9) is a feature geometry representing a number of 'choices'; it is not the representation of an individual segment. (10), however, is the representation of a particular segment (English /k/), in which these choices have been made. Thus [DORSAL] has been chosen from the set of nodes dominated by the Place node, while each of the binary nodes under [DORSAL] has been assigned a value.

[11] For a discussion of the various types of dependency relationships in feature geometry, see Ewen (1995: §3).

before introducing this system, we must first consider the fact that there have been influential attempts to represent the kind of asymmetry involved in privative oppositions without giving up the strict binarity hypothesis.

The kind of approach which maintains strict binarity in the face of asymmetry might be desirable on one of two grounds. On the one hand, it restricts the number of feature types, and hence is to be preferred over a theory with a proliferation of feature types, all other things being equal. On the other, it has been claimed that, even though many features are 'basically' privative, in the manner discussed above for [nasal], there are nevertheless circumstances, however rare, in which reference to the opposite pole is required. In other words, even though '+' is the pole of [nasal] to which phonological rules and processes normally refer, they may sometimes also refer to [–nasal]. A harmony process in which spreading was blocked by any segment with the value [–nasal] would also provide evidence that, contrary to what we have claimed, [–nasal] can be an active value in the phonology of a language. If this state of affairs is indeed found in languages, i.e. that reference to the 'opposite pole' is required, then it can be claimed that all features are binary.

We consider now how the notion of asymmetry between feature-values can be accounted for within a theory which maintains the binarity hypothesis. Notice first that the asymmetry between the values of at least some of the binary features which we have been discussing has always been recognised as something which needs to be accounted for, even in strictly binary theories. In *SPE*, for example, a complex set of **marking conventions** was established. On the basis of the kinds of considerations introduced above, and some to which we will return in the course of this section, one of the two values of certain binary features was characterised as *m* (marked), and the other as *u* (unmarked), instead of the normal '+' and '–' values. In cases where it was claimed that there was no reason to assume asymmetry, such as [back], the latter values were retained. Associated with this was an 'evaluation metric', whereby features having the value *u* for a particular segment were 'cost-free', and those with the value *m* contributed to the 'cost' (i.e. phonological complexity) of the segment in question. In (11) we give the matrices for the vowel features for a system containing the vowels /i e ɑ o u y/, in terms of this approach:

(11)

	/i/	/e/	/ɑ/	/o/	/u/	/y/
[high]	u	m	u	m	u	u
[low]	u	u	u	u	u	u
[back]	–	–	u	+	+	–
[round]	u	u	u	u	u	m
complexity	1	2	0	2	1	2

The 'cost' of a segment is established simply by adding the number of marked specifications to the number of '+'s and '–'s. As noted above, such representations were associated with a set of marking conventions, which spelled out the value of *u* and *m* for particular features. (12) (from *SPE*: 405) is an example of such a convention:

(12)
$$[u\ \text{low}] \rightarrow \begin{Bmatrix} [+\text{low}] \,/\, \begin{bmatrix} \overline{} \\ u\ \text{back} \\ u\ \text{round} \end{bmatrix} \\ [-\text{low}] \end{Bmatrix}$$

Thus the unmarked value for [low] is '+' for a vowel which is unmarked for backness and roundness, and '–' otherwise (i.e. /ɑ/ ([+low]) is unmarked, but for all other vowels [–low] is unmarked).

We leave it to the reader to examine the kinds of claim that are being made with respect to relative complexity in (11), i.e. claims of the following sort: for front vowels it is unmarked to be unrounded, and for non-low vowels it is unmarked to be high. Indeed, we shall devote no further space to markedness theory in this form, as it has largely been replaced by an alternative approach within Binary Feature Theory, to which we now turn.[12]

2.2.1 *Underspecification*

Recent approaches within the binary model to the asymmetry problem have utilised the notion of **underspecification**. In this conception of segmental structure, the marked value for a feature is underlyingly specified, while the unmarked value is absent in phonological representations, and is filled in by rule in the course of the derivation of the surface phonetic representations. We can represent this position formally as in (13), where we return to the kinds of representations introduced at the beginning of this chapter:

(13)
$$\begin{array}{llll} \text{a.} & [+\text{nas}] & \text{b.} & \qquad\qquad [\text{nasal] tier} \\ & \quad | & & \circ \\ & \quad \circ & & | \\ & \quad | & & \\ & \begin{bmatrix} +\text{son} \\ +\text{cons} \end{bmatrix} & & \begin{bmatrix} -\text{son} \\ +\text{cons} \end{bmatrix} \\ & \quad /\text{m}/ & & \quad /\text{b}/ \end{array}$$

Thus the nasal consonant is underlyingly specified for nasality, but the oral consonant is **unspecified** for this feature, so that the segment as a whole is

[12] For a demonstration of the inadequacy of markedness theory as formulated in *SPE*, see e.g. Lass and Anderson (1975: App. IV), Kean (1980).

'underspecified', i.e. it does not bear a specification for every feature. It will be clear that this position comes very close in spirit to that in (3). Both approaches express the fact that non-nasality is not a positive property, but the claim in (13) is that this is no more than the 'normal' case; it is still formally possible to characterise cases where non-nasality apparently functions in the characterisation of phonological processes, by appealing to the value [–nasal], which can be introduced by a rule. A 'strict privativist', however, clearly has to show that analyses making use of [–nasal] are flawed. Equally, though, it is incumbent on a 'binarist' employing underspecification to show that such analyses are in fact required in the phonology of some language.

In underspecification theory, then, only the marked value of a feature is underlyingly specified; the unmarked (or **default**) value is added in the course of the derivation, so that the *surface* representation of (13) will be identical to (2).

2.2.2 *Redundancy*

We should notice at this point that the mechanism of underspecification can also be used to express something other than relative markedness. English, for example, is a language in which all non-low back vowels are rounded, as there are no vowels such as */ɯ ɤ/. In other words, if a vowel has the features [–low, +back], then we know it must be [+round]. Halle (1959) pointed out that it is thus not necessary to specify non-low back vowels as [+round] phonologically: as the feature [round] is not distinctive (or contrastive) for non-low back vowels, it can be left underlyingly unspecified. The value [+round] is thus **redundant**, i.e. predictable on the basis of other feature specifications. Notice that this is a different type of claim from those we have been considering with respect to markedness and asymmetry, in that we are not making any general claims about whether it is more natural for non-low back vowels to be rounded or unrounded. Rather, it is an automatic consequence of the structure of the vowel system of English that the value of this particular feature should be non-contrastive, and thus predictable and phonologically redundant.

Such a state of affairs can be represented by a **redundancy constraint** such as that in (14):

(14) if [–low, +back] then [+round]

However, although the two reasons for not specifying a particular value for a binary feature in phonological representations – lack of markedness and redundancy – are logically independent, they are not unrelated. Consider the two potential redundancy constraints in (15), for example:

(15) a. if [+low] then [+round]
b. if [+low] then [–round]

While (15b) characterises a state of affairs frequently encountered in languages of the world, (15a) would be unexpected: there are virtually no languages without an /a/ or an /ɑ/-type vowel. In other words, on the basis of (15b), which expresses a redundancy (non-contrastiveness) in many languages, [–round] can be left unspecified for low vowels. On grounds of markedness, we would reach exactly the same conclusion: [–round] is in general the unmarked value for low vowels, and could therefore be left unspecified.

However, unmarked values are not *necessarily* non-contrastive in a particular system. Consider the feature [nasal], for which, as we have seen, [–nasal] is the unmarked value. In English, however, [–nasal] is a contrastive value: the only difference between English /m/ and /b/, let us assume, is that /m/ is nasal, while /b/ is not. In an approach to binary features which does not incorporate considerations of markedness, both values will be lexically specified, as in (2).

In the following two sections we consider underspecification approaches in more detail. Let us first, however, consider a slightly different way in which phonological representations can be simplified. It will be quite obvious that no single language makes use of the whole set of features (whatever its content) to classify the inventory of contrastive segments (i.e. phonemes). Languages like English or Dutch, for example, do not make use of lexical contrasts which require the use of laryngeal features characterising *degree* of glottal opening, which does not play a contrastive role in these languages. There is no opposition between breathy and creaky voiced segments, or between aspirated and unaspirated stops, for example. This means that the features involved, whatever their precise character, are redundant 'as a whole', and do not require to be specified lexically. Notice that this situation is different from those which we have just been discussing, where one of the *values* of a feature may be redundant in some context. Features which are redundant at the phonological level, however, may be used phonetically, for example to express allophonic variation. In most dialects of English, initial voiceless stops become aspirated before stressed vowels. This implies that voiceless stops in this context are assigned a value for whatever feature characterises aspiration (see §2.7 for discussion of the features characterising these laryngeal phenomena, though in a different framework). The same process does not take place in Dutch, for example.

However, in the remainder of this chapter we consider the underspecification of values, rather than features which may be absent from the lexical specification. In the next two sections we discuss two approaches to the notion of underspecification introduced above. In §2.2.3 we discuss underspecification on the basis of redundancy (**contrastive specification**) and in §2.2.4 underspecification on the basis of markedness (**radical underspecification**).

2.2.3 Contrastive specification

Consider a language which has a system of five contrastive vowels, as in (16):

(16)

	/i/	/u/	/e/	/o/	/ɑ/
[high]	+	+	–	–	–
[low]	–	–	–	–	+
[back]	–	+	–	+	+
[round]	–	+	–	+	–

This feature matrix contains redundant information. The feature [round] can be omitted entirely from the lexical specification, since no pair of vowels is distinguished by this feature; cf. the discussion in the previous section.[13]

To distinguish the vowel /ɑ/ from all the other vowels in (16) it is sufficient to specify it as [+low], since there are no other vowels which are [+low]. We can leave out the other specifications for this vowel, and fill in these values using the redundancy statements or constraints in (17):

(17) a. if [+low] then [–high]
b. if [+low] then [+back]

Notice that redundancy constraints do not express phonological *processes* as such. Rather, they constitute statements about a particular inventory of segments. Because of this, the existence of a redundancy constraint in a particular language allows us to derive from it another redundancy constraint by the following principle, familiar from formal logic:

(18) $(A \rightarrow B) \rightarrow (\sim B \rightarrow \sim A)$

(i.e. if $A \rightarrow B$ is true then $\sim B \rightarrow \sim A$ is also true). This entails that if the redundancy constraints in (17) are true for a particular system, then those in (19) must also be true:

(19) a. if [+high] then [–low]
b. if [–back] then [–low]

[13] We might have chosen to omit [back], rather than [round]. On grounds of contrastiveness, there is no reason to choose one rather than the other as the feature to be omitted from (16): in either case, we end up with an underspecified display like (20) below. See Schane (1973) for discussion of the relationship between the two features.

These statements allow us to simplify the matrix in (16) as in (20), in which all non-contrastive values and features are omitted:

(20)

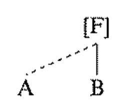
	/i/	/u/	/e/	/o/	/ɑ/
[high]	+	+	–	–	
[low]				–	+
[back]	–	+	–	+	

We should note that the status of the (a) and (b) sets of constraints in (17) and (19) is different. The constraints in (a) must be true in every language, given the definitions of the features [high] and [low]. Hence these redundancy constraints express 'universal' properties of the system.[14] Those in (b), on the other hand, are only true if the language in question lacks a contrast between low front and low back vowels. Thus if a language has both /a/ [+low, –back] and /ɑ/ [+low, +back], then the (b) constraints do not hold. Hence these constraints are part of language-specific grammars. Languages with the same number of vowels tend to have very similar systems, resulting from the fact that certain feature specifications are preferred over others.

In the approach to underspecification known as **Contrastive Specification Theory** (cf. Steriade 1987; Clements 1988; Archangeli 1988a; Mester and Itô 1989), only redundant values can be left unspecified, and the possibility of underspecification on grounds of markedness is not utilised.

Contrastive Specification Theory differs in one crucial way from early models of generative phonology. In these earlier models, phonological rules could make reference only to 'fully specified matrices', i.e. those in which all feature-values were specified.[15] Contrastive Specification Theory, on the other hand, allows rules to operate on segments for which redundant values have not yet been specified by the application of redundancy constraints. This position allows us to provide a more satisfactory characterisation of various types of phonological phenomena, in particular those involving assimilation processes. Recall from §1.4 that assimilation is characteristically viewed in non-linear phonology as the spreading of a feature to another segment, in the manner represented in (21):

(21)



[14] We might argue that the need to state universal redundancies of this sort is a reflection of the inadequacy of the feature system in question. It seems more desirable to have a model of segmental structure in which universally impossible states of affairs cannot be described, rather than one in which we require extra mechanisms of this sort.

[15] See for discussion Stanley (1967), Ringen (1975), Kiparsky (1982).

However, assimilation of this sort need not involve *strictly* adjacent segments, in spite of examples such as (72) in Chapter 1, which, we argued, showed that nasality could not spread from a consonant to a vowel across an intervening lateral, for example. Indeed, in our discussion of the vowel harmony phenomena of Turkish in §1.4.2, we tacitly assumed that segments could be skipped, as is shown by an examination of (88) in Chapter 1. There we see that the spreading feature ignores all intervening consonants.

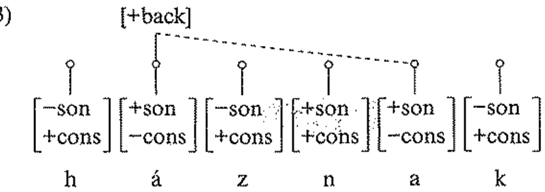
The same kind of trans-segmental transparency holds for umlaut processes such as the Old English case discussed in §1.4.1. Again, consonants intervening between the vowels involved in this kind of spreading process typically seem to take no part in the process. That is, they are not in themselves affected by the spreading – they remain unchanged – nor do they prevent the spreading feature from reaching the 'target' vowel. In a feature system like that discussed in §1.3.2, vowel features such as [high], [low] and [back] are, within Contrastive Specification Theory, not required for the lexical specification of consonants (except in languages which display contrasts between tongue-body (i.e. dorsal) consonants, e.g. between palatals and velars, or which have contrasts involving secondary articulations such as velarisation or palatalisation, which might involve a contrast between [+back] and [–back]). In Hungarian, for example, the feature [back] is lexically contrastive for vowels, but its specification is redundant for consonants: there are no contrasts between consonants involving just the feature [back]. Like Turkish, Hungarian is a vowel harmony language. The feature involved in Hungarian harmony, [back], spreads from vowel to vowel, but leaves intervening consonants unaffected:

(22)	NOM SG	DAT SG		
	ház	háznak	[hɑːznɔk]	'house'
	öröm	örömnek	[œrœmnɛk]	'joy'

Contrastive Specification Theory allows us to say that the consonants in the dative forms in (22) are unspecified for the feature involved in the spreading process. Thus the absence of any specification for [back] straightforwardly accounts for the fact that the backness property of a stem vowel can spread to the vowel of an affix, even though this involves spreading across another segment:[16]

[16] An issue which arises here is the motivation for treating the specification of 'vowel' features on consonants as redundant, and hence added in the course of the derivation by redundancy rule, rather than as being omitted entirely from consonantal specifications, even at the surface level.

(23)

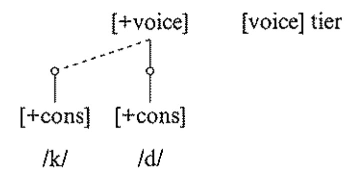


Further evidence for skipped segments being unspecified for features involved in spreading can be found from processes involving voicing assimilation among consonants. In Dutch, for example, syllable-final voiceless obstruents become voiced if a following syllable-initial obstruent is also voiced, as illustrated in (24):

(24)	zakdoek	'handkerchief'	/zɑkduk/ → [zɑgduk]
	kasboek	'cashbook'	/kɑsbuk/ → [kɑzbuk]

The details of how this process operates, and the restrictions on it, need not concern us here, but it clearly involves the leftward spreading of [+voice], a process which, at first sight, we might formalise as in (25):

(25)

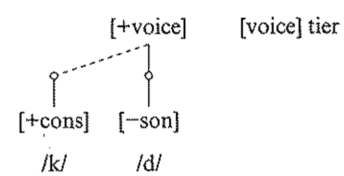


However, voiceless obstruents followed by a *sonorant* consonant do not become [+voice], as shown in (26):

(26)	kruidnagel	'clove'	/krøydnaːɣəl/ → [krøytnaːɣəl][17]
	Parklaan	(street name)	/pɑrklaːn/ → [pɑrklaːn]

At first sight this seems unexpected, since sonorants (like voiced obstruents) are phonetically [+voice]. The most straightforward way of characterising the process would seem to be to say that the process simply requires the trigger to be [–sonorant], as in (27):

(27)



[17] Notice that the final consonant of *kruid*, which is underlyingly voiced, undergoes Final Devoicing (cf. (12a) in Chapter 1).

This certainly accounts for the facts, and as such is adequate, but it is also very unrevealing. In particular, it fails to show *why* the spreading process should be restricted to obstruents, and what it is about sonorant consonants which prevents them from spreading voice into a preceding obstruent.

In an approach which allows underspecification, such as Contrastive Specification Theory, there is a straightforward way of representing the phenomenon. In Dutch there is no contrast between voiced and voiceless sonorants: Dutch does not have segments such as */l̥/ or */m̥/. Thus [+voice] is phonologically redundant for sonorant consonants, and need not be specified. Because sonorant consonants lack the [+voice] specification, then, they do not trigger voicing assimilation. Thus our original formulation in (25) is adequate: any consonant which is marked as [+voice], i.e. any voiced obstruent, spreads [+voice] to a preceding consonant, while any consonant which is *not* [+voice], i.e. either a voiceless obstruent, which is of course [−voice], or a sonorant consonant, which is simply unspecified for the feature, does not participate in the assimilation process.

It is interesting to notice the behaviour of sonorant consonants with respect to voicing assimilation in Russian (see Hayes 1984b; Kiparsky 1985). In Russian, the value for the feature [voice] of all members of an obstruent cluster is determined by the final member of the cluster, as shown by the forms in (28) (from Hayes 1984b: 318; Kiparsky 1985: 103; notice that (28) shows that the assimilation process takes place both word-internally and across various types of morphological boundaries):

(28)	a.	zub-ki	'little teeth'	/zubki/	→ [zupki]
	b.	Mcensk#by	'if Mcensk'	/mtsɛnskbɨ/	→ [mtsɛnzgbɨ]
	c.	Mcensk##byl	'it was Mcensk'	/mtsɛnskbɨl/	→ [mtsɛnzgbɨl]
	d.	mozg	'brain'	/mɔzg/	→ [mɔsk]

In *zubki* in (28a), the voiced labial stop is devoiced under the influence of the following voiceless /k/. That this is not a question of final devoicing, which is found in other contexts in Russian, is demonstrated by (28b, c), where the morpheme-final voiceless obstruent cluster is voiced by spreading from the /b/. Indeed, final devoicing may feed the assimilation process; in (28d) /g/ is devoiced in final position, and then triggers voicing assimilation of the preceding fricative.

Consider now the forms in (29):

(29)	a.	iz Mcenska	'from Mcensk'	/iz mtsɛnska/	→ [is mtsɛnska]
	b.	ot mzdy	'from the bribe'	/ɑt mzdɨ/	→ [ɑd mzdɨ]

Here we see that the voicing specification of an obstruent spreads across an intervening sonorant, which we must therefore assume is unspecified for [voice].

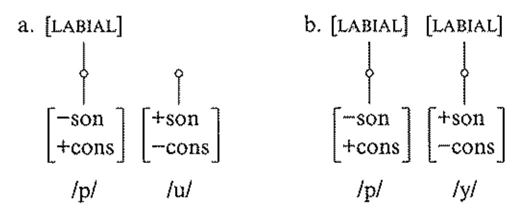
That is, in *iz Mcenska* in (29a), the voiced alveolar fricative is devoiced under the influence of the following voiceless /ts/, even though a sonorant consonant intervenes. In *ot mzdy* in (29b), the morpheme-final voiceless alveolar stop is voiced by spreading from the /z/. On the analysis given here, such a case is similar to the harmony and umlaut cases considered above.

Another case of this type is discussed by Yip (1988: §5.4). In Cantonese Chinese there are various constraints on the co-occurrence of labial consonants and rounded vowels in the same syllable. One such constraint states that a syllable-final labial consonant cannot be preceded by a rounded vowel, so that sequences such as */tup, køm/ are impossible, whereas forms like /tip/ are permitted. This is an example of a dissimilation constraint, which states that two segments cannot be associated to the same value for a particular feature.[18]

A second constraint involves syllable-initial labial consonants, which can be followed by /u/ or /o/, but not by /y/ or /ø/ (/puk, mou/ vs */pyk, møy/). This constraint is thus weaker than the previous one, in that back rounded vowels may combine with labial consonants, but not front rounded ones. Why should this be?

As we have seen, labial consonants are dominated by the [LABIAL] node (cf. (8) above). Phonetically, of course, all the vowels /u o y ø/ are [+round], and thus also dominated by the [LABIAL] node. However, for the (non-low) back vowels, this is a redundant feature, because there are no back unrounded vowels corresponding to rounded /u o/ in Cantonese. Underlyingly, then, /u o/ are unspecified for [LABIAL], and thus a sequence of a labial consonant and /u/ or /o/ does not violate the dissimilation constraint in question, as shown in (30a). However, the same does not hold for the front rounded vowels, which are in opposition with /i e/, and for which [LABIAL] is lexically contrastive (30b):

(30)



Because both labial consonants and front rounded vowels are lexically specified as [LABIAL] in Cantonese, a sequence of the two violates the dissimilation constraint.

[18] Yip ascribes this to the operation of the Obligatory Contour Principle (cf. §1.4), which prohibits 'adjacent identical elements'.

Examples like these suggest that allowing rules to make reference to representations in which redundant feature-values are omitted is more than a mere notational economy. It straightforwardly expresses the observed fact that redundant information *behaves differently* from non-redundant information, i.e. it is simply ignored by spreading processes and constraints.[19]

Notice that the redundancies we have been considering up to now are **intrasegmental**, i.e. certain feature-values of a segment are predictable, regardless of the environment in which this segment occurs, purely on the basis of other specifications of the same segment. Such constraints are also referred to as **segment structure constraints**. Certain specifications may also, however, be predictable on the basis of the context in which a particular segment occurs, either with respect to the value(s) of particular features in neighbouring segments, or because of its position in, say, the syllable. Thus, given a syllable-initial sequence of three consonants in English, we know that the first one can only be /s/, and so all feature-specifications except [+consonantal] are redundant. This kind of situation is characterised by **phonotactic constraints**.[20]

In this section we have shown that Contrastive Specification Theory restricts the non-specification of feature-values to situations in which that value is not contrastive in the language in question. We turn now to a theory of underspecification which, in addition, extends the non-specification mechanism to cases of relative markedness.

2.2.4 *Radical underspecification*

In our discussion in §2.1 we introduced the notion of asymmetry. We saw that the two values of a binary feature often behave differently, in that only one of the two typically occurs in the characterisation of phonological constraints and processes, the other doing so less typically or not at all. In other words, only one of the values may define a natural class, as we illustrated with respect to the feature [nasal]: the set of [+nasal] sounds forms a class which can be appealed to in phonological processes, while the set of [–nasal] sounds is apparently not available. In §2.2 we gave a brief sketch of how relative markedness of this kind was dealt with in *SPE*.

In recent approaches to asymmetry, underspecification has been employed instead of the marking conventions of markedness theory. This theory is

[19] Clearly, we also need to establish whether there are phonological processes which do make reference to redundant information. It has been argued that such cases do in fact exist, which would imply that at some stage in the derivation redundancy rules apply, which then feed a second class of phonological rules.

[20] In *SPE* phonotactic constraints were referred to as morpheme structure constraints; later treatments (e.g. Vennemann 1972) characterise them as syllable structure constraints. The term 'phonotactic constraints' is more general than either.

commonly referred to as **Radical Underspecification Theory** (see e.g. Archangeli 1988a; Archangeli and Pulleyblank 1994). Radical Underspecification Theory goes a step further than Contrastive Specification Theory, which eliminates only those feature-values which are redundant. For any 'asymmetric' feature, such as [nasal], Radical Underspecification Theory specifies only one value of a feature in underlying representations, leaving the other value to be added by rule in the course of the derivation. The value which is found underlyingly is the one which typically defines a natural class in that language. For the feature [nasal], then, the underlying value would normally be [+nasal]. Thus, as we noted in §2.2.1, in underspecification theory, it is the marked value of a feature which is underlyingly specified; the default value is added by rule. Within Radical Underspecification Theory, in the vast majority of cases, *no* feature has both values underlyingly specified in a particular language; effectively, then, Radical Underspecification Theory claims that in general all features are asymmetric: no feature is underlyingly equipollent.

This latter claim means that we will have to decide for each feature which value can be left underlyingly unspecified, i.e. which of the two values is the 'expected' one. This is not straightforward, especially as the theory allows different solutions for different languages, as we shall see. However, let us first explore the mechanism employed within Radical Underspecification Theory for relating underlying representations to surface representations. Feature asymmetry is expressed by a set of **default rules**. The set in (31) would generate the **fully specified** matrix in (16) for a language with the vowel system /i u e o ɑ/:

(31) a. [ ] → [–high]
b. [ ] → [–low]
c. [ ] → [–back]

The value of a feature which is added by a default rule is the one that is not referred to by the phonological rules of the language in question, while the opposite value of that feature is the one that is present in the underlying lexical representation of a segment. Thus the claim made in (31c), for example, is that it is [+back], rather than [–back], which is involved in processes such as spreading. Assuming the set of default rules in (31), (32) gives the underlying representations of the vowels in (16):

(32)

	/i/	/u/	/e/	/o/	/ɑ/
[high]	+	+			
[low]					+
[back]		+		+	+

Crucially, only one of the values for each feature in (32) is found; none of the features is underlyingly specified for both values.

If we compare (32) with (20), in which only the non-contrastive (i.e. redundant) feature-values were omitted, we see that the default rules render many of the redundancy constraints superfluous. Every redundancy constraint which fills in a value identical to that filled in by default, such as (17a) and (19), will apply vacuously. This filling in of the default value is the typical pattern, so that in Radical Underspecification Theory, only one redundancy constraint is still required for the system in (16), that in (33):

(33) if [+low] then [+back]

This means that (34), rather than (32), is the 'radically underspecified' underlying representation of the vowel system in (16):

(34)	/i/	/u/	/e/	/o/	/ɑ/
[high]	+	+			
[low]					+
[back]		+		+	

The properties of a radically underspecified underlying system are formally rather different from the corresponding system in Contrastive Specification Theory, where only the redundant specifications have been removed. The underlying representations are no longer formally contrastive, in the sense of Contrastive Specification Theory, in that the representation of a particular segment may in (34) formally 'include' the representation of some other segment. Thus, although the phonological representation of /i/ contains only the specification [+high], it is not the only [+high] vowel in the system. Similarly, the vowel /e/ is entirely unspecified, and therefore its representation is not formally contrastive. Such a state of affairs would be impossible in Contrastive Specification Theory, as in (20), where no representation can be formally 'ambiguous'. Notice, though, that in Radical Underspecification Theory, the underlying representation of each vowel in a system is still unique: there are no pairs of segments with identical feature specifications, and therefore the representation of any segment is different from all others.

It is clear that the choice of which value is present in underlying representations determines both the lexical representation of a segment and the set of default rules in a language. If we were to assume different default rules for the example which we have been considering, say by taking [–high] as underlyingly specified, we would have the set of default rules and redundancy constraints in (35):

(35) a. *Default rules*
[ ] → [+high]
[ ] → [–low]
[ ] → [–back]

b. *Redundancy constraints*
if [+low] then [–high]
if [+low] then [+back]

These would yield the lexical representations in (36):

(36)	/i/	/u/	/e/	/o/	/ɑ/
[high]			–	–	
[low]					+
[back]		+		+	

Archangeli (1988a) argues that both options (and indeed others) are available, although only one of them will be 'expected'. Thus it is assumed that [+high] *generally* represents the default rather than [–high]. On grounds of complexity we might prefer (35), which yields a set of underlying representations in which the relatively simple high vowel /u/, for example, has a less complex representation than its mid counterpart, /o/.

Proponents of Radical Underspecification Theory claim that in any system there is typically one segment which is underlyingly *completely* unspecified. In other words, phonological systems tend to have one 'special vowel', i.e. one that fails to take part as expected in various phonological processes, in particular behaving as if it were absent, or invisible to phonological processes such as vowel harmony, or one that typically occurs as the default **epenthetic** vowel, i.e. the vowel that is inserted in contexts in which for some reason a vowel is required, but where its particular specifications for the vowel features are unimportant. Thus Khalkha, a Mongolian language, displays a vowel harmony process by which low vowels agree in roundness with the first vowel of the word, as in [dɔlɔːn-ɔːs] 'seven (ABL)' and [gɵrɵːsn-ɵːs] 'antelope (ABL)'.[21] However, a non-initial /i/ behaves as if it is invisible to rounding harmony: if the initial vowel is round, an /i/ in the second syllable neither undergoes harmony (i.e. it surfaces as [i]) nor prevents roundness from spreading to following syllables, as is evidenced by the form [ɵtʃigdɵr] 'yesterday'. The status of this vowel can be reflected in the underlying representations of Khalkha Mongolian by leaving it completely unspecified, i.e. 'empty'. In turn, the identity of the empty vowel in any system will determine the choice of which value of a particular feature should be underlyingly present and which should be added by default rule. Thus in (34) it is /e/ which is unspecified for all features, and therefore predicted to behave as the empty vowel; in (36) it is /i/.

Let us now look at a slightly more complicated example, the vowel system in (37), which represents one stage of Old English (see Hogg 1992a):

[21] See Svantesson (1985) for a discussion of vowel harmony in Khalkha.

(37)

	/i/	/y/	/u/	/e/	/ø/	/o/	/æ/	/ɑ/
[high]	+	+	+	−	−	−	−	−
[low]	−	−	−	−	−	−	+	+
[back]	−	−	+	−	−	+	−	+
[round]	−	+	+	−	+	+	−	−

We use the same set of default rules as in (31) and furthermore assume that '−' is the unmarked value for [round]. This gives the set of default rules and redundancy constraints in (38):

(38) a. *Default rules*
[ ] → [−high]
[ ] → [−low]
[ ] → [−back]
[ ] → [−round]

b. *Redundancy constraint*
if [+back, −low] then [+round]

This allows the Old English system to be represented as in (39):

(39)

	/i/	/y/	/u/	/e/	/ø/	/o/	/æ/	/ɑ/
[high]	+	+	+					
[low]							+	+
[back]			+			+		+
[round]		+			+			

Finally, consider a vowel system like that of Turkish, with both back rounded and back unrounded vowels:

(40) *Default rules*
[ ] → [−high]
[ ] → [−back]

Notice that (40) does not contain a default rule for [round], so that we have (41) for the Turkish vowel system:

(41)

	/i/	/y/	/ɨ/	/u/	/e/	/ø/	/ɑ/	/o/
[high]	+	+	+	+				
[back]			+	+			+	+
[round]		+	−			+	−	

(41) differs from the other radically underspecified underlying systems which we have considered, in that we find both [+round] and [−round], i.e. *both* values of a single feature. However, although it may appear that we are thereby abandoning the radical underspecification claim, i.e. that each feature has only one value present in underlying representations, this is in fact not quite the case. Rather, the suggestion here is that whether or not a particular value is marked is partially a function of the other features involved

in the representation of a segment. As far as roundness is concerned, it is unmarked for non-low back vowels to be [+round], whereas for front vowels [−round] is the unmarked value. English is not atypical in this respect, in having no front rounded vowels such as /y ø/, and no non-low back unrounded vowels such as /ɯ ɤ/. This means that we can add the default rules in (42) to the set in (40):

(42) *Default rules*

$$[\ ] \rightarrow [+\text{round}] \,/\, \begin{bmatrix} \_\_ \\ +\text{back} \end{bmatrix}$$

$$[\ ] \rightarrow [-\text{round}] \,/\, \begin{bmatrix} \_\_ \\ -\text{back} \end{bmatrix}$$

Notice that the rules which we have added to (42) are indeed default rules: they only apply to a segment which does not bear a value for [round] underlyingly. Thus, /y/ in (41), which already bears the marked value [+round], will not be subject to the default rule affecting [−back] vowels.

We have seen that Radical Underspecification Theory goes further than Contrastive Specification Theory, in allowing underspecification on the basis both of redundancy (i.e. non-contrastiveness) and of relative markedness. It is clear that this approach leads to a situation in which, typically, only one value for a particular feature is required underlyingly (in spite of cases such as that just mentioned, where binarity seems to play a crucial role), and it might be asked whether this approach is not largely the same as one in which the notion of binarity is abandoned, and replaced by a system incorporating features which can only have one value *anywhere* in the phonology. We now turn our attention to this matter.

2.3 Single-valued features

As we have seen, proponents of Radical Underspecification Theory claim that there are various grounds for claiming that features must have two values, even though only one value per feature is required underlyingly. This means that we require various formal mechanisms such as default rules for linking underlying representations involving underspecification to fully specified surface representations.

The reasons for retaining the binarity assumption in Radical Underspecification Theory are of various types, as we have observed. Firstly, some languages appear to take the normally unmarked value of a feature as the one that is lexically specified, i.e. as the one which is marked. This seems to be the case in the harmony system of Yoruba, which we discuss in some detail in §2.4.3. Secondly, there seem to be processes in languages which show evidence that we have to refer to *both* values of some feature, either underlyingly or at some point in the course of the derivation. Our analysis of the feature [round] in Turkish in (41) provides an example of this. Thirdly, as observed by Chomsky and Halle (1968), markedness can be context-dependent. So one value may be marked in context A, while the other is marked in context B. Thus it is unmarked for obstruents to be voiceless in syllable-final position, but voicelessness is marked in intervocalic position, at least following a stressed syllable. Fourthly, a spreading process may be blocked by the presence of a segment bearing the 'opposite value' of the feature involved in the spreading.

As we have already observed, an alternative to an approach incorporating the radical underspecification of binary features would be one based on the notion of single-valued features. A system based on binary features, such as Radical Underspecification Theory, is, all other things being equal, a more complex theory of representation than one in which every feature is single-valued, i.e. has only one value at *all* levels of the derivation. In a single-valued approach, the vowel /y/ in a language might differ from /i/ in having a specification [round], which /i/ would lack altogether, both at the phonological and at the phonetic level. Thus the fact that it is marked for front vowels to be round (see the discussion in the previous section) would be reflected by the fact that, throughout the phonology, /y/ would have an extra property, roundness, as compared with /i/. This approach to vowel features is the same as that implied by (3), in which we characterised the distinction between nasal and non-nasal sounds as involving the presence vs the absence of a single-valued feature [nasal].

Notice that adopting single-valued features would mean that the set of default rules would become superfluous, and that the interpretation of the 'non-specification' of a feature would not be a phonological issue, but would be a matter entirely for the phonetic component.[22] This would clearly constitute a formal simplification, if the arguments which suggest that binary features are required can be successfully refuted.

A single-valued feature approach can be seen as an extreme form of Radical Underspecification Theory, in which the idea that one of the values of a feature is typically the default value is carried to its logical conclusion. The claim of **Single-valued Feature Theory** is simply that default values play no role in the phonology whatsoever, and so features do not have such default values: each feature is single-valued. Thus a single-valued system reflects the

[22] We assume here that the output of the phonological component – let us call it the 'surface phonological representation' – forms the input to a 'phonetic component', whose function is to provide a detailed set of phonetic instructions for the realisation of the string being generated.

spirit of underspecification in expressing markedness considerations directly, but it does so in a more rigorous way.

Single-valued features have been introduced in various ways into phonological analyses. Some approaches, such as the model of feature geometry considered in §2.1.1, allow certain features to be single-valued, while others are binary. Another approach is that of Goldsmith (1985), who proposes a model in which a particular feature may be single-valued in one language, but binary in another, according to the behaviour of the feature in phonological processes in the languages in question. Still other phonologists claim that *all* features are single-valued.[23]

As we have seen, the use of single-valued features seems to lead to a reduction of the complexity of the phonological machinery. Consider the various mechanisms which we associated with the underspecification theories discussed above. We distinguished 'redundancy constraints', associated with Contrastive Specification Theory, and 'default rules', associated with Radical Underspecification Theory. As we have already noted, if we introduce consistently single-valued features, the category of default rules is no longer required. Clearly, as the function of default rules is to 'fill in' the value of the feature which is not specified in lexical representations, they have no role in a single-valued approach, where each feature only has one value. Let us illustrate this by considering the vowel system in (43), for which we give first a radically underspecified representation in which the redundancy constraints have not applied:

(43)

	/i/	/e/	/ɑ/	/o/	/u/	/y/	/ø/
[high]	+				+	+	
[low]			+				
[back]			+	+	+		
[round]				+	+	+	+

In anticipation of our arguments for a particular set of single-valued features for characterising the vowel space, let us construct a single-valued equivalent of (43), using three features. These are [front], [low] and [round] (where we assign [low] a rather wider interpretation than in a binary approach; we will say that any vowel which is not [+high] in binary terms is [low] in single-valued terms).[24] This gives us the system in (44), where we represent [front] as

[23] This position has been defended most extensively by proponents of dependency phonology (e.g. Anderson and Jones 1974, 1977; Anderson and Ewen 1987) and government phonology (e.g. Kaye *et al.* 1990; Harris 1994), but has been increasingly adopted in various forms in recent years. See also the approach within the model of particle phonology of Schane (1984), and the work of Rennison (e.g. 1986).

[24] A more appropriate definition might be in terms of acoustic properties, specifically relative sonority, whereby low vowels are, all other things being equal, more sonorous than high vowels. For ease of exposition, however, we will continue to use the articulatory label.

i, [low] as **a** and [round] as **u** (from now on, we indicate single-valued features by the use of boldface):

(44)

	/i/	/e/	/ɑ/	/o/	/u/	/y/	/ø/	
	i	**i**				**i**	**i**	**i** tier
		a	**a**	**a**			**a**	**a** tier
				u	**u**	**u**	**u**	**u** tier

The representations in (44) are underlying, but are nevertheless 'fully specified', in the sense that there is nothing that can be added. 'Default rules' are simply not formally relevant in a single-valued approach. On the other hand, redundancy constraints may still be required in systems, although on a much more restricted scale than in underspecification theories: (44), for example, displays no such redundancies, whereas (43) contains redundancies which can be filtered out by virtue of the constraints in (45):

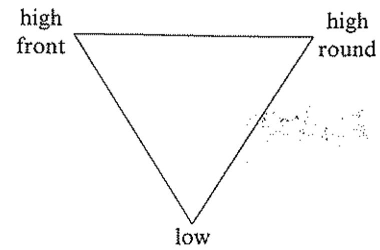
(45) *Redundancy constraints*
a. if [+low] then [+back]
b. if [+back, −low] then [+round]

We consider the matter of redundancies in relation to a single-valued system in §2.4.3; however, we notice at this point that if we were to find a three-vowel system containing the vowels /i u æ/, the representation of /æ/ would contain a redundancy even in a single-valued system: its surface representation would contain both **i** and **a**, while **i** would be omitted from its underlying representation, in that its occurrence would be predictable, and therefore redundant.

Single-valued Feature Theory essentially makes the claim that the difference between the underlying lexical phonological representation and the surface phonological representation is minimal – in the case under discussion here, they are identical. It is in this sense that the phonological 'machinery' is simplified by the adoption of a single-valued model.

As we have already anticipated, single-valued feature systems generally differ from the *SPE* system not only in feature type, but also in the choice of different parameters for characterising the vowel space. As we showed in (21) of Chapter 1, the *SPE* system is essentially rectangular, in that the features divide up the vowel space into points on the high–low and the front–back dimensions, with lip-rounding being superimposed on these two dimensions. The feature systems associated with Single-valued Feature Theory, however, are generally **tridirectional**, in accordance with the traditional view of the vowel space as triangular, as in (46):

(46)



As is illustrated by (46), the three basic primes which tridirectional feature systems characteristically employ in their feature set correspond to the three extremes of the vowel triangle. As suggested above, the articulatory realisations of these three primes are typically high front, high round and low, as shown in (47):[25]

(47) *Single-valued vowel features*
i 'high frontness'
u 'high roundness'
a 'lowness'

From a phonetic point of view, these features, which on their own would represent the vowels /i/, /u/ and /ɑ/ (as in (44)), are clearly basic. They correspond to the **quantal** vowels (Stevens 1972, 1989), i.e. those vowels which are acoustically particularly 'stable' in that their acoustic effect can be achieved with a fairly wide range of articulatory configurations. In addition, these three vowels are maximally distinct, both from an acoustic and an articulatory point of view. Moreover, /i/, /u/ and /ɑ/ are also basic as far as phonology is concerned. Systems containing just three vowels typically have vowels in the /i/, /u/ and /ɑ/ regions, and these are also the first vowels that children acquire. Hence the choice of **i**, **u** and **a** as basic vocalic features is well motivated, both phonetically and phonologically.

The fact that a single-valued feature in isolation characterises a complete segment has often been claimed to be a major advantage of the system. That is, each feature is in itself a phonetically interpretable 'element'.[26] In binary models, however, feature-values do not have this property; the fact that a segment has the value [−back] says nothing about the values for any other

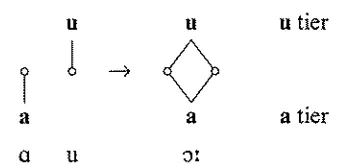
[25] Other features beside these three have been proposed (see §§2.4.3 and 2.5 below). However, for the present, we restrict the discussion to the characterisation of the vowel set described in binary terms by the features [high], [low], [back] and [round].

[26] Single-valued features are generally referred to as elements within government phonology (see §3.8). For discussion of the desirability of the notion that elements should be phonetically interpretable, see e.g. Harris (1994: §3.2.3).

features. Contrast this with the single-valued model, where **i** on its own is the representation for the vowel /i/. Inherent in this approach is the claim that vowels which are not represented by a single feature are 'mixtures' of the basic vowels /i/, /u/ and /a/. Thus Harris (1994: 97) refers to /i u a/ as 'simplex' and /e o y/ as 'compound', while Donegan (1973), although working with binary features, refers to 'pure' and 'mixed' vowels. A mixed vowel such as /e/, then, contains the element which in isolation characterises /i/ as well as the element which in isolation characterises /ɑ/, but each element is less 'strong' than it would be when it occurs alone in the representation of a vowel. In simple articulatory terms, /e/ is front, but less front than /i/, and low, but less low than /ɑ/.[27]

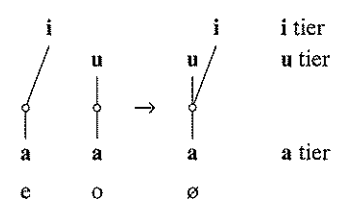
Processes involving diphthongisation or monophthongisation have often been cited in support of these claims. In a binary approach, a diphthongisation process involves the addition of a new feature-matrix, whereas in a single-valued model it is claimed that the only change involves the rearrangement of features which are already present. For example, the change from Middle English /klɑu/ to Modern English /klɔː/ 'claw' can be represented as in (48):

(48)



The association of the features to the root nodes is the only change that takes place. A similar process is cited by Jones (1989: §2.4.4) and by Hogg (1992b: 215), who note that the Old English diphthong /eo/ in e.g. *eorþe* 'earth' monophthongised to a front rounded vowel /ø/ in certain dialects of Middle English, as represented in (49):

(49)



Here, as before, the two segments have undergone **fusion**, so that the various features are now associated with a single segmental node.

[27] As we saw in note 24, an articulatory definition of **a** is less revealing than one based on acoustic properties; indeed, it is probably the case that this also holds for **i** and **u**.

Unlike the vowel system in (44), many systems do not have front rounded vowels. The incorporation of single-valued features in a feature geometry approach to the representation of segments allows us to characterise this in terms of **tier conflation** (see e.g. Kaye *et al.* 1985; Harris 1994: 102). In a system without front rounded vowels the **i** and **u** features share a single tier, and so can never combine, as in the system in (50):

(50)	/i/	/e/	/ɑ/	/o/	/u/	
	i	**i**		**u**	**u**	**i/u** tier
		a	**a**	**a**		**a** tier

Similarly, in a vowel system with only the three 'basic' vowels, such as that of Alaskan Eskimo (see e.g. Lass 1984b: 85), the three vowel feature tiers are conflated into one:

(51)	/i/	/ɑ/	/u/	
	i	**a**	**u**	**i/u/a** tier

We have seen that the three single-valued features introduced here allow us to characterise the seven vowels in (44). However, at first sight this seems to be the maximum, given that the features simply co-occur in the representation of a vowel; there are apparently no other combinations of the three features available. It will be obvious that these seven representations do not exhaust the maximum number of different vowels found in the language systems of the world. The existence of systems containing more than seven vowels means that there must be some way in which the total number of vowels describable in terms of (combinations of) the three basic vocalic components can be increased. We return to this issue in §2.5.

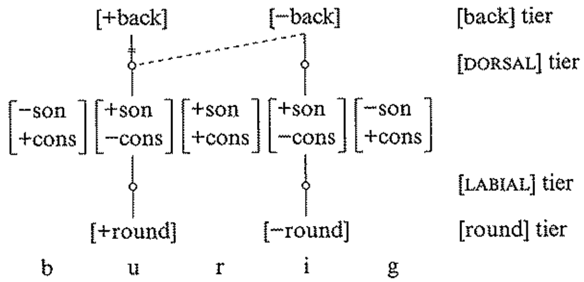
2.4 Umlaut and harmony processes

In this section we consider a number of cases involving umlaut and harmony which will illustrate the workings of Underspecification Theory and Single-valued Feature Theory, and will address some of the issues raised in previous sections.

2.4.1 Umlaut

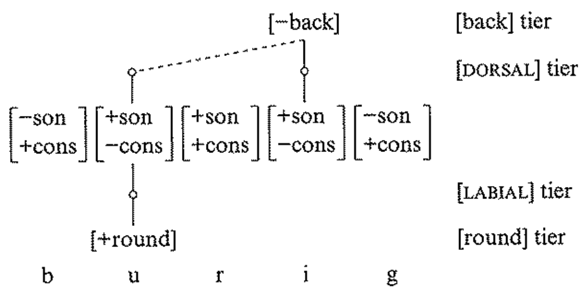
In §1.4.1 we saw that Old English *i*-umlaut (OEIU) involved the autosegmental spreading of [–back], in binary terms, from a suffix to a stem. We formulated the spreading in the word *byrig*, the dative singular form of *burg* 'city', as (80) in Chapter 1, repeated here in slightly adapted form as (52):

(52)



(For reasons which will become clear, we have included the feature [round] in (52).) Spreading of [−back] necessarily involved a second process, the delinking of the lexically associated [+back] value on the first vowel. In a radically underspecified approach, this latter stage is no longer required. On the assumption that [−back] is the value which is active in the phonology of Old English, as is evidenced by the fact that it spreads, it is the marked value, and therefore lexically present. [+back] is the default value, and therefore not present when the umlaut process applies, so that the formulation in (53) is sufficient in Radical Underspecification Theory:

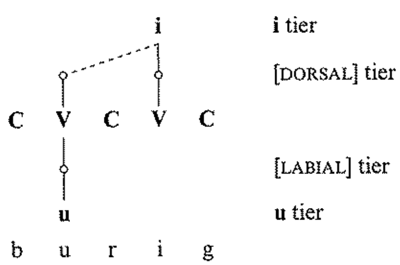
(53)



(We further assume that [+round] is the marked form, and so omit [−round].) As the first vowel is now associated with a specification on the [back] tier, the default rule will not apply to it.

Consider now a single-valued formulation of the same process, which at first sight looks more or less identical:

(54)



(For illustration, we replace the binary feature [consonantal] with the single-valued features **C** and **V**; this does not affect our argument here, but see §2.6 for discussion.)

Just as in Radical Underspecification Theory, the process involves the spreading of a feature from the suffix vowel to the stem vowel. The feature involved is the frontness feature; underlyingly, the lexically back vowel is not associated with a feature on this tier (hence its renaming as the **i** tier).

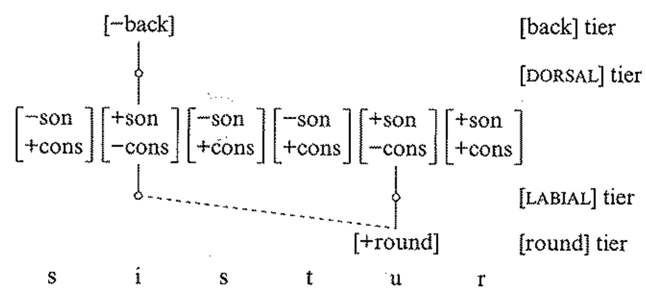
In what sense do (53) and (54) differ, then, other than in the 'name' of the feature involved? In both cases, 'frontness' is characterised as the spreading property involved, either as [−back] or as **i**. The Radical Underspecification approach means that [−back] is the underlyingly present value for Old English. However, the possibility that another language might exist with a process which is identical, except that [+back] is the spreading value, and therefore the underlyingly present value in that language, is not excluded. The single-valued approach, on the other hand, makes the prediction that 'backness' can never spread, as it is not an addressable feature in the system.

Before we consider whether this prediction is correct, we examine another umlaut process, Old Norse *u*-umlaut (ONUU), which involves front vowels becoming rounded under the influence of a following /u/ or /w/. Some examples are given in (55):

(55)	i > y	/systur/	'sister'	(< *swistur)
	e > ø	/tøgr/	'ten'	(< *tegur)
	ɑ > ɔ	/lɔndum/	'land (DAT PL)'	(< *lɑndum)

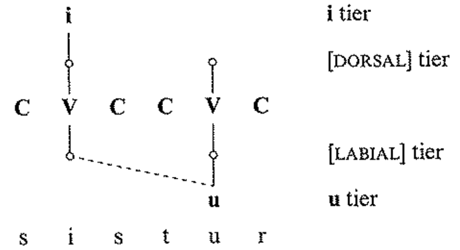
The philological details of ONUU are highly complex (cf. Gordon 1957: 273; Benediktsson 1963), and, as in the case of OEIU, the triggering environment (/u/ or /w/) is often lost, and is therefore not to be found in the orthography. A possible representation of the umlaut of *systur* in terms of Radical Underspecification Theory is given in (56):

(56)



while a single-valued equivalent is given in (57):

(57)

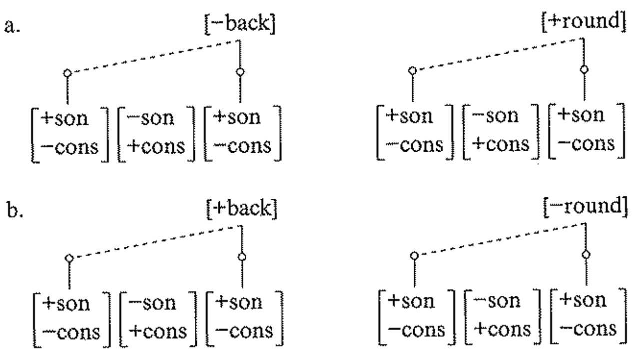


Just as in the case of OEIU, the choice of [+round] as the underlyingly present value in (56) suggests that in a Radical Underspecification approach to this phenomenon [+round] is the underlying value in Old Norse, but, equally, that it would be possible to find a language in which the spreading value was [–round]. The single-valued approach, on the other hand, predicts that we will not find such a language: 'unroundedness' is not a property in the system.

In this respect the single-valued approach seems to make the correct prediction. While the umlaut processes in (58a) are indeed recorded, as we have seen, those in (58b), as far as we know, are simply not attested:

(58) a.

b.



While it is possible to formulate the rules in (58b) for the two putative but unattested types of umlaut, which must therefore be excluded in Radical Underspecification Theory by explicit statement, in Single-valued Feature Theory it is simply impossible to formulate rules which would represent these processes, as there is nothing corresponding to the spreading values [+back] and [–round]. All other things being equal, then, the latter theory seems to give a more adequate account of umlaut processes.

2.4.2 *Vowel harmony in Yawelmani*

We turn now to a case which has been influential in the development of Radical Underspecification Theory (see Archangeli 1984), but which also

provides interesting support for a single-valued approach (Ewen and van der Hulst 1985). This concerns the analysis of vowel harmony in Yawelmani, a dialect of Yokuts, a language spoken in California. As this language has a small vowel system (having only /i/, /u/, /ɑ/ and /o/), and a relatively straightforward harmony rule, we will consider the analysis of this phenomenon in terms of each of the three approaches we have introduced in this chapter, viz. Contrastive Specification Theory, Radical Underspecification Theory and Single-valued Feature Theory.

The Yawelmani vowel system can be given the fully specified feature representation in (59):

(59)

	/i/	/u/	/ɑ/	/o/
[high]	+	+	–	–
[round]	–	+	–	+
[low]	–	–	+	–
[back]	–	+	+	+

The vowel harmony process involves the rounding of an unrounded vowel in a suffix after a rounded vowel in the stem with the same value for the feature [high], as illustrated in (60), from Kenstowicz and Kisseberth (1979: 78ff.):

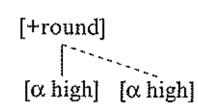
(60) a. xɑt-nit 'will be eaten'
bok'-nit 'will be found'
xil-nit 'will be tangled'
dub-nut 'will be led by the hand'
b. xɑt-xɑ 'let us eat'
bok'-xo 'let us find'
giy'-xɑ 'let us touch'
dub-xɑ 'let us lead by the hand'

(60a) shows that /i/ in a suffix is realised as [u] if the stem contains /u/; (60b) shows /ɑ/ in a suffix being realised as [o] if the stem contains /o/. This state of affairs can be characterised in a linear formulation as in (61):

(61) a. /i/ → [u] / /u/ C __
b. /ɑ/ → [o] / /o/ C __

Archangeli (1984) gives the non-linear formulation of the rule as (62):

(62)



(where the use of 'α' indicates that the two vowels must have the same value for the feature [high]).

Consider now the analysis of this system within Contrastive Specification Theory. Recall that only feature-values which are redundant, in the sense that they are non-contrastive, can be omitted from the phonological representation. Given the vowel system in (59), it is clear that we can omit all the values for the features [low] and [back], according to the following set of redundancy constraints:[28]

(63) a. if [+high] then [−low]
b. if [+round] then [+back]
c. if [+round] then [−low]
d. if [−high, −round] then [+back, +low]
e. if [+high, −round] then [−back]

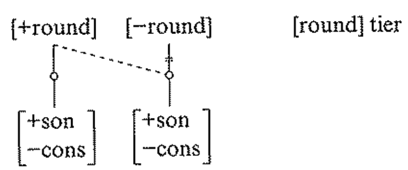
This leaves us with the non-redundant specifications in (64):

(64)

	/i/	/u/	/ɑ/	/o/
[high]	+	+	−	−
[round]	−	+	−	+

None of the remaining feature-values can be omitted within a Contrastive Specification approach, as each is required to distinguish one segment from at least one other.

As the harmony rule in (62) is formulated in terms of the spreading of [+round], and all vowels are specified for the feature [round] in a Contrastive Specification approach, then it is clear that the application of the rule will involve feature *change*, as shown in (65):

(65)


(For convenience we ignore the fact that the two vowels must have identical height specifications.) The [+round] specification spreads from the first vowel to the second, with subsequent delinking of the second vowel from its original [−round] specification.

(66) shows the derivation of the various vowels from their underlying representations within a Contrastive Specification approach. (66a) show the derivation of vowels when not affected by harmony; (66b) the derivation of /i ɑ/ when they are affected by rounding harmony:

[28] A different set of redundancy rules might be chosen, e.g. if [+low] then [−high, −round, +back]. This would, of course, yield a different set of phonological representations.

(66)

	a. *no harmony* /i/	/u/	/ɑ/	/o/	b. *harmony* /i/	/ɑ/	
[high]	+	+	−	−	+	−	underlying
[round]	−	+	−	+	−	−	representation →
[high]	+	+	−	−	+	−	harmony (65) →
[round]	−	+	−	+	+	+	
[high]	+	+	−	−	+	−	redundancy (63)
[round]	−	+	−	+	+	+	
[low]	−	−	+	−	−	−	
[back]	−	+	+	+	+	+	
	[i]	[u]	[ɑ]	[o]	[u]	[o]	

Let us now consider the same problem, analysed within a Radical Underspecification approach, which dispenses with the need to change features. In accordance with the claim that no feature has both values specified underlyingly, Archangeli (1984) proposes the following two default rules for Yawelmani, in addition to the redundancy rules in (63):

(67) a. [ ] → [+high] b. [ ] → [−round]

Thus the underlying representations are:

(68)

	/i/	/u/	/ɑ/	/o/
[high]			−	−
[round]		+		+

Notice that /i/ is now underlyingly unspecified for all features.

As (68) is radically underspecified, we can revert to the original formulation of the harmony rule in (62), where delinking plays no role. The derivation of the harmonising vowels in Yawelmani then involves the stages shown in (69):

(69)

	a. *no harmony* /i/	/u/	/ɑ/	/o/	b. *harmony* /i/	/ɑ/	
[high]			−	−		−	underlying
[round]		+		+			representation →
[high]	+	+	−	−	+	−	default (67a) →
[round]		+		+			
[high]	+	+	−	−	+	−	harmony (62) →
[round]		+		+	+	+	
[high]	+	+	−	−	+	−	default (67b) →
[round]	−	+	−	+	+	+	
[high]	+	+	−	−	+	−	redundancy (63)
[round]	−	+	−	+	+	+	→
[low]	−	−	+	−	−	−	
[back]	−	+	+	+	+	+	
	[i]	[u]	[ɑ]	[o]	[u]	[o]	

Notice that we first apply the default rule for [high], as the harmony rule in (62) makes reference to this feature. Within the Radical Underspecification approach, this ordering is regulated by a convention referred to as the **Redundancy Rule Ordering Constraint**, formulated in (70):

(70) *Redundancy Rule Ordering Constraint* (RROC)
Any [redundancy or default] rule assigning [αF], where 'α' is '+' or '–', applies before the first rule in which reference is made to [αF].

According to the RROC, the Yawelmani harmony rule, which makes reference to the feature [high], triggers the previous application of the default rule assigning [+high].

After application of (62), the default rule for [round] applies, assigning [–round] to any segment not specified as [+round] (either underlyingly or as a result of harmony), and finally, as in Contrastive Specification theory, the redundancy rules operate.

Finally, we consider how we can deal with Yawelmani vowel harmony in terms of a single-valued feature system. We assume the three single-valued features introduced above, viz. **i** (frontness), **u** (roundness) and **a** (lowness). On this assumption, the *surface* representation of the Yawelmani vowel system will be as in (71):

(71)	[i]	[u]	[ɑ]	[o]
	i	**u**	**a**	**u,a**

(Here and elsewhere we adopt the convention that two single-valued features appearing in the representation of a segment are linked by a comma, so that **u,a** is a vowel containing both the features **u** and **a**.)

Up to now we have been assuming that Contrastive Specification Theory, Radical Underspecification Theory and Single-valued Feature Theory are distinct, although related, theories of phonological representation. However, it is clear that within Single-valued Feature Theory we can envisage two approaches. In the approach which we have been adopting in the discussion above, the representations in (71) would also be the underlying representations, since no redundancies are involved. As we have argued, in this form of single-valued theory, no 'redundancy rules' corresponding to (63) are required: underlying representations already meet the criterion of 'contrastive specification'.

We have also argued that the default rules of Radical Underspecification Theory are not required in a single-valued approach. This is certainly true if default rules are merely required to 'fill in' the value of a feature which is not lexically specified. These rules are sometimes referred to within Radical

Underspecification Theory as **complement rules**, because the value which is filled in is the complement of the value which is lexically specified. However, as we have seen, Archangeli's 'radical' analysis of Yawelmani in (68) involves the claim that /i/ is the 'unspecified' vowel and thus has no underlying specification. It is possible to adopt this aspect of Radical Underspecification Theory in a single-valued approach, by omitting the frontness component from underlying representations, to give (72):

(72)	[i]	[u]	[ɑ]	[o]
		u	**a**	**u,a**

where only /i/ differs from its corresponding surface representation. We can then formulate the default rule to assign the frontness component as (73):

(73) V
|
→ **i**

i.e. a vowel which remains empty is assigned the frontness component, and surfaces as [i]. Notice that this is not a 'complement rule', but a rule which makes a specific claim about the nature of the 'unmarked' feature in Yawelmani.

The Yawelmani harmony rule simply involves spreading of **u**, as in (74):

(74) **u**　　　　**u** tier

V　**V**

The derivation of the various surface vowels in a single-valued framework involves the application of the two rules in (73) and (74), as shown in (75):

(75) a. *no harmony*				b. *harmony*		
/i/	/u/	/ɑ/	/o/	/i/	/ɑ/	
	u	**a**	**u,a**		**a**	underlying representation
	u	**a**	**u,a**	**u**	**u,a**	harmony (74)
i	**u**	**a**	**u,a**	**u**	**u,a**	default (73)
[i]	[u]	[ɑ]	[o]	[u]	[o]	

2.4.3 Vowel harmony in Yoruba

We turn now to a rather more complex case of harmony. This involves Yoruba, a Niger-Congo language spoken in Nigeria, the analysis of whose harmony system has played an important role in establishing and motivating Radical Underspecification theory (e.g. Pulleyblank 1988a; Archangeli and Pulleyblank 1989).

Standard Yoruba has a seven-vowel system, in which the mid vowels are generally analysed as differing from each other in their value for the feature [Advanced Tongue Root] ([ATR]; see §1.3.3):

(76)

	/i/	/e/	/ɛ/	/a/	/ɔ/	/o/	/u/
[high]	+	–	–	–	–	–	+
[low]	–	–	–	+	–	–	–
[back]	–	–	–	+	+	+	+
[ATR]	+	+	–	–	–	+	+

Yoruba has a vowel harmony system involving the feature [ATR]. Mid vowels (/e ɛ o ɔ/) must agree in their value for [ATR], as shown by (77); the forms in (77a) show the combinations of mid vowels which are permitted by the harmony constraints, while the corresponding forms in (77b), containing two mid vowels with *different* values for [ATR], are prohibited (data from Archangeli and Pulleyblank 1989: 177; ´ = high tone, ` = low tone, mid tone is not marked and /p/ is realised as [k͡p]):

(77)	a.	ebè	'heap for yams'	ɛsɛ̀	'foot'
		epo	'oil'	ɛ̀kɔ	'pap'
		olè	'thief'	ɔbɛ̀	'soup'
		owó	'money'	ɔkɔ̀	'vehicle'
	b.	*ɛbè		*esɛ̀	
		*ɛpo		*ɛ̀kɔ	
		*ɔlè		*obɛ̀	
		*ɔwó		*okɔ̀	
	c.	*eba		*osa	

In addition, the sequence in (77c), i.e. a [+ATR] mid vowel followed by [–ATR] /a/, is prohibited.

We might expect from this data that any pair of vowels in a Yoruba disyllabic word would have to have the same value for this feature. But this is not so, as we summarise in (78):

(78) a. /i/ and /u/ ([+ATR]) can combine with any preceding or following vowel.
b. /a/ ([–ATR]) can be followed by /e/ or /o/ ([+ATR]).

We give some representative forms in (79):

(79)	a.	ilɛ̀	'land'	ɛ̀bi	'guilt'
		itɔ́	'saliva'	ɔ̀kín	'egret'
		ilá	'okra'	àdí	'palm nut oil'
	b.	ate	'hat'	àwo	'plate'

We will now, following Archangeli and Pulleyblank, examine the assumptions we need to make regarding formal representations in order to deal with the facts within a Radical Underspecification approach. We can propose the default rules and redundancy constraints in (80):

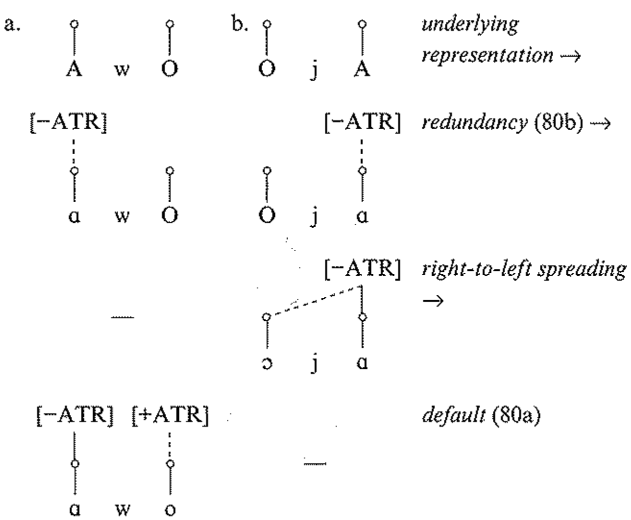
(80)	a.	*Default rules*	b.	*Redundancy constraints*
		[ ] → [+high]		if [+low] then [–high]
		[ ] → [–low]		if [+low] then [+back]
		[ ] → [–back]		if [+low] then [–ATR]
		[ ] → [+ATR]		if [+high] then [+ATR]

This gives the radically underspecified representations in (81):

(81)

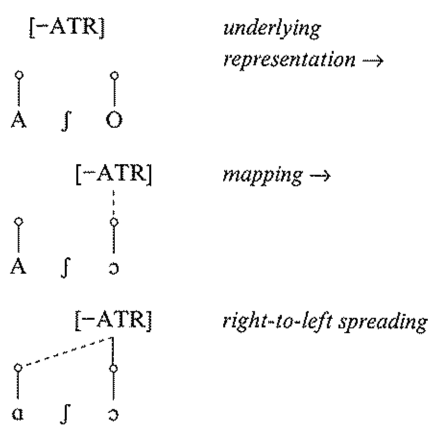
	/i/	/e/	/ɛ/	/a/	/ɔ/	/o/	/u/
[high]		–	–		–	–	
[low]				+			
[back]					+	+	+
[ATR]			–		–		

As can be seen in (81), Archangeli and Pulleyblank take [–ATR] to be the underlying value. Consider first words containing the low vowel /a/. We have seen that /a/ can be followed by any mid vowel, whether [+ATR] or [–ATR], but cannot be *preceded* by a [+ATR] mid vowel (/e/ or /o/). (82) gives the derivation of two words containing /a/, [àwo] 'plate' and [ɔjà] 'market' (we use capital letters to indicate lexical representations in which the feature [ATR] is unspecified):

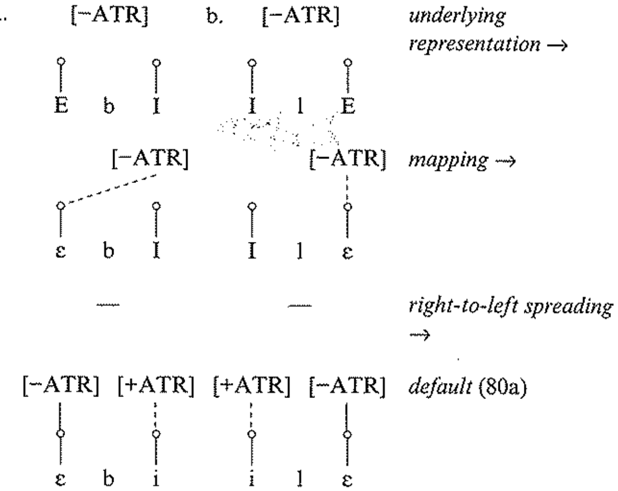
(82)


If Yoruba had left-to-right [–ATR] spreading, (82a) would incorrectly be realised as *[ɑwɔ]. Notice that the redundant [–ATR] specification for low vowels is assigned before the harmony rule spreading [–ATR] applies, by virtue of the Redundancy Rule Ordering Constraint (70). If this were not the case, then spreading would be unable to operate.

However, a word such as [ɑwɔ] would also be well formed in Yoruba, as we would expect, given that both the vowels here are [–ATR], so that there is no question of a harmony violation. Thus we find forms such as [ɑʃɔ] 'cloth' and [ɑjɛ] 'paddle'. Archangeli and Pulleyblank suggest that forms such as these can be generated by allowing a morpheme in Yoruba to have a floating feature on the [ATR] tier in the underlying representation. In other words, just as in our discussion of Turkish vowel harmony in §1.4.2, a morpheme may contain a [–ATR] feature which is initially not associated with a vowel. Furthermore, mapping (cf. our discussion of tone in §1.4) must target the final vowel of the morpheme. On this assumption, the derivation of [ɑʃɔ] proceeds as in (83):

(83)


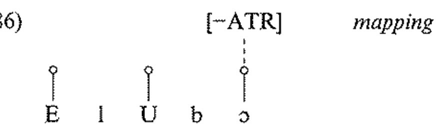
A similar account is available for words in which high vowels co-occur with [–ATR] vowels, as in (79a) above. These words, too, will have a floating [–ATR] autosegment. However, [–ATR] will not be able to associate to a high vowel, because of the redundancy constraint in (80b) which rules out high [–ATR] vowels. If the high vowel is final, as in [ɛ̀bi] 'guilt', floating [–ATR] associates with the first available vowel, i.e. the preceding non-high one. By default (80a), the final vowel becomes [+ATR], as in (84a). If, however, the high vowel is in the first syllable, as in [ilɛ̀] 'land' in (84b), [–ATR] is mapped onto the final vowel as normal, but fails to associate with the first vowel, which is high.

(84)


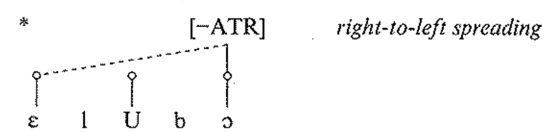
However, although (84a) shows that floating [–ATR] can skip a final high vowel, and be mapped onto a preceding non-high vowel, it apparently cannot spread *across* a high vowel. Evidence for this comes from trisyllabic words such as those in (85):

(85) a. èlùbɔ́ 'yam flour' b. *ɛlubɔ
odídɛ 'grey parrot' *ɔdidɛ

On the assumption that these words again have a floating [–ATR], the first step in the derivation of [èlùbɔ́] involves mapping [–ATR] onto the final vowel:

(86)


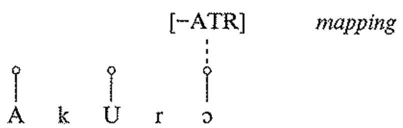
As before, [–ATR] cannot spread to the high vowel in the second syllable, However, it also does not spread to the vowel in the first syllable, as we see from the unacceptability of (85b). This possibility is excluded by the assumption that a spreading rule cannot simply skip a segment to which it cannot associate, as this would involve **discontinuous feature sharing**, as in (87):

(87) *


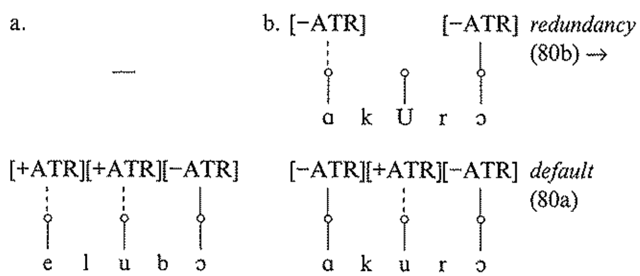
Facts like these provide further evidence for an important property of phonological representations, viz. that feature sharing must involve adjacent class nodes (cf. the discussion in §1.4 with respect to line crossing).[29] At first sight, though, the form in (88) appears to violate this constraint, in that here the first and third vowels are [–ATR], while the second is [+ATR]:

(88) àkùrɔ̀ 'a type of farmland'

However, no violation is in fact involved. As in [èlùbɔ́], [–ATR] cannot spread to the vowel in the second syllable because it is [+high], and cannot cross this vowel to spread to the vowel in the first syllable. Thus at this point the two derivations are essentially identical:

(89)


In (86) the [ATR] values for the vowels in the first two syllables is determined by default (80a): they are both [+ATR]. This also holds for the second vowel in (89). However, (89) is subject to the redundancy constraint in (80b), which determines that [+low] vowels are [–ATR]. This redundancy constraint applies before the default specification is determined, so that the derivations continue as follows:

(90)


These forms do not involve spreading, then, but are rather the result of the interaction of the default rules and redundancy constraints of Yoruba given in (80).

The analysis we have just given is one in which [–ATR] is the lexically specified feature-value, and [+ATR] the default value. This is cross-linguistically an atypical situation; most languages in which [ATR] plays a role in the

[29] Notice that, here as elsewhere, we assume that consonants, which do not participate in vowel harmony processes, simply lack the class node with which [ATR] associates. The fact that they are ignored by vowel harmony processes is not a violation of this constraint, then.

phonology would select [+ATR] as the underlying value. If the analysis given is the appropriate one, as Archangeli and Pulleyblank argue, then we have clear evidence in favour of the view that this is a binary feature, with both values being available in phonological processes. This analysis of Yoruba thus presents an interesting challenge to the claim that all features are single-valued.

Alternative analyses are possible, however. Indeed, an analysis of Yoruba vowel harmony in which no reference is made to [–ATR] is available in a system making use of the single-valued features **i**, **u**, **a** and ATR. This analysis depends on treating the vowels /e/ and /o/ not as the [+ATR] counterparts of /ɛ/ and /ɔ/, as in Archangeli and Pulleyblank's account, but as the [–ATR] counterparts of the high vowels /i/ and /u/. There are good phonetic grounds for this claim: high [–ATR] vowels and mid [+ATR] vowels are acoustically very similar, and are notoriously hard to distinguish.

Assuming a single-valued system with a feature ATR, this would yield the following representation of the Yoruba vowel system:

(91)

/i/	/e/	/ɛ/	/a/	/ɔ/	/o/	/u/	
i	**i**	**i**					**i** tier
		a	**a**	**a**			**a** tier
				u	**u**	**u**	**u** tier
ATR						ATR	ATR tier

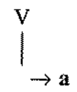
Thus the only ATR vowels are /i/ and /u/. Abandoning [–ATR], of course, means that the harmony process of Yoruba must be reanalysed as involving the spreading of some other feature. We suggest that this feature is **a**.

Let us consider how such an analysis might work. In Archangeli and Pulleyblank's analysis, as we have already seen, [–ATR] was not allowed to associate with a high vowel. Something similar is required here; we have to prevent **a** from spreading to /i/ and /u/. This can be achieved by the mechanism of tier conflation introduced in §2.3:

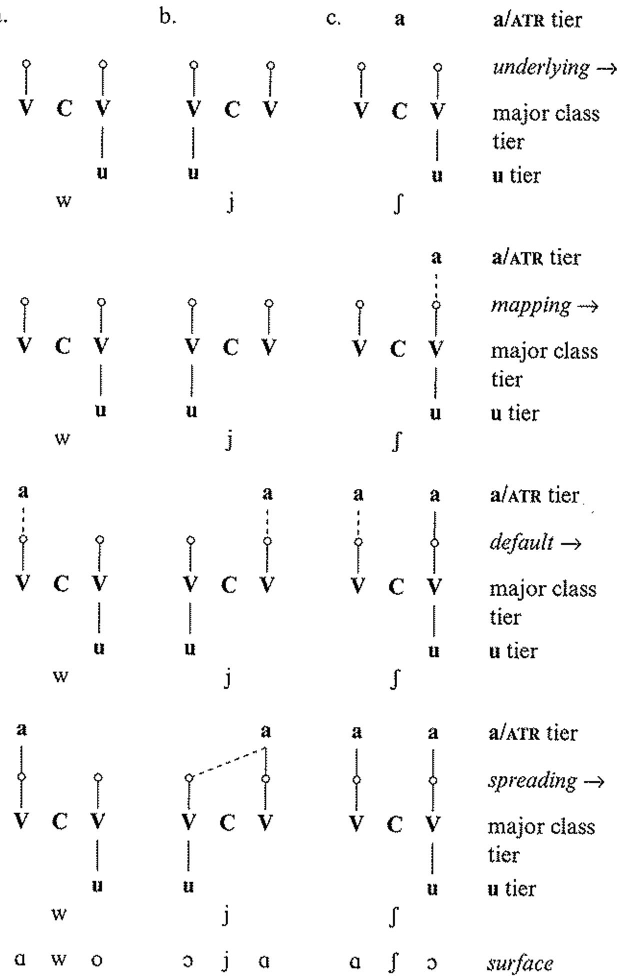
(92)

/i/	/e/	/ɛ/	/a/	/ɔ/	/o/	/u/	
i	**i**	**i**					**i** tier
ATR		**a**	**a**	**a**		ATR	**a**/ATR tier
				u	**u**	**u**	**u** tier

That is, the features **a** and ATR, which share a tier, cannot combine in the representation of a segment, so that spreading of **a** to a high vowel is formally impossible. In addition, we assume that the Redundancy Rule Ordering Constraint of Binary Feature Theory (70) operates in the single-valued model to assign a default feature to a vowel which is completely empty, prior to the first application of any rule which mentions the feature. For Yoruba, the default rule is that in (93) (cf. the default rule for Yawelmani in (73)):

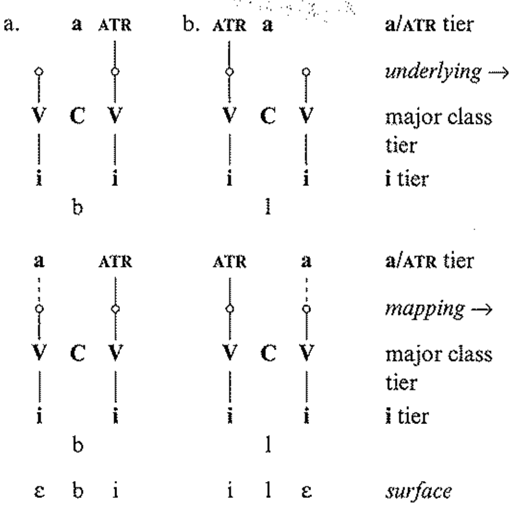
(93)


This allows the following derivations of the Yoruba bisyllabic words in (82) and (83) above, where we retain Archangeli and Pulleyblank's analysis in terms of a floating feature, in this case **a**:

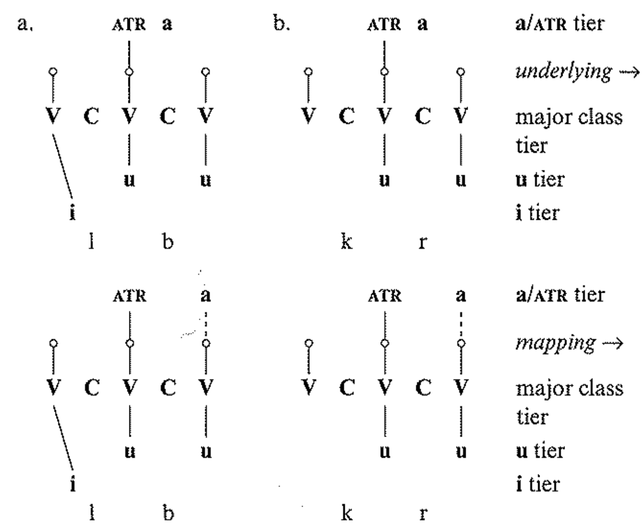
(94)


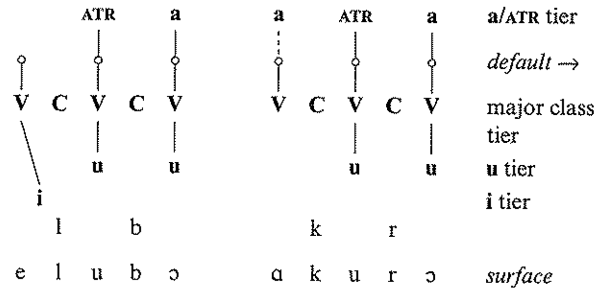
Mapping takes place in (94c), as before. Before spreading takes place, empty vowels are assigned the default feature **a**. This renders spreading in (94c) vacuous.

Consider now the forms containing high vowels in (84). In the single-valued analysis their derivations proceed as in (95):

(95)


a cannot be mapped on to the high vowel /i/ in (95a), which already has a specification (ATR) on the relevant tier, nor can it spread to the first vowel in (95b), for the same reason. The trisyllabic forms [èlùbɔ́] and [àkùrɔ̀] are dealt with as might be expected:

(96)




As in (94), there is no spreading.

Although it is not our concern here to argue the relative merits of the binary and single-valued models in any detail, we have shown here that what appears at first sight to be a clear case of the spreading of an 'unexpected' binary feature value ([–ATR]) can be given an interpretation within single-valued theory by attributing the spreading to a different feature, which already forms part of the feature inventory for the language in question.

2.5 Dependency within the segment

We noted in §2.3 that the combinations of the three single-valued features **i**, **u** and **a** apparently allow a maximum of seven distinct representations, those given in (44). However, especially in view of our discussion in §1.3.3, it is clear that we must consider how we should view vowel systems with a more extensive array of vowels. Recall that in §1.3.3 we suggested that vowel systems can be organised in different ways. In one kind of system, that in (28) in Chapter 1, the vowels divided into two sets, a [+ATR] set and a [–ATR] set. Alternatively, the two sets can involve an opposition between peripherality and centrality, which we characterised in terms of a tense vs lax opposition, as in (26) in Chapter 1. Lastly, we observed that there is evidence that we can identify a multivalued scalar vowel-height opposition in certain systems, involving four distinctive vowel heights.

Let us first consider systems organised in terms of ATR oppositions. In our discussion of Yoruba in §2.4.3 we introduced a single-valued feature ATR, and it will be clear that it is the presence of this feature which distinguishes the members of the two sets of this kind of system, as shown in (97):

(97)	/i/	/e/	/ə/	/o/	/u/	/ɪ/	/ɛ/	/ɑ/	/ɔ/	/ʊ/	
	i	**i**				**i**	**i**				**i** tier
		a	**a**	**a**			**a**	**a**	**a**		**a** tier
				u	**u**				**u**	**u**	**u** tier
	ATR	ATR	ATR	ATR	ATR						ATR tier

We are assuming here a system in which ATR is a 'positive' property, rather than one like Yoruba, which is atypical in this respect. A system such as (97) allows a straightforward interpretation of harmony in terms of the spreading of the ATR feature.

As yet, however, we do not seem to be able to account within single-valued theory for the second type of system, that involving a distinction between peripheral and central vowels. Most proponents of Single-valued Feature Theory have suggested that a further feature is necessary to deal with these systems, a feature which on its own is interpretable as a schwa-like vowel. This feature is referred to variously as **neutral** (Harris 1994: §3.3.5), **centrality** (Anderson and Ewen 1987: §6.2) and **cold** (Kaye *et al.* 1985: §1.2), because of the fact that central vowels have less well-defined acoustic properties than peripheral vowels. Following Harris (1994), we represent the neutral feature here as @. A system organised in terms of a tense vs lax opposition, such as (26) in Chapter 1, can now be characterised as in (98):

(98)	/i/	/e/	/ɑ/	/o/	/u/	/ɪ/	/ɛ/	/ə/	/ɔ/	/ʊ/	
	i	**i**				**i**	**i**				**i** tier
		a	**a**	**a**			**a**	**a**	**a**		**a** tier
				u	**u**				**u**	**u**	**u** tier
						@	@	@	@	@	@ tier

The lax vowels differ from the tense vowels in the presence of @.

Accounting for a system in which we have a scalar opposition of vowel height is less straightforward, however. It does not seem appropriate simply to add a new feature (or to utilise either ATR or @), as we have argued that a *single* phonetic parameter is involved here. Rather, it seems that we have to increase the combinatorial potential of the three features **i**, **u** and **a**.

There are in principle two ways in which this can be achieved. Either we can assume that features can occur more than once in a particular representation, or we can take the view that one of the features in a feature combination can be in some sense more prominent than the other feature(s). The first of these two positions is defended by Schane (1984), while the concept of **dependency** is used to create a larger number of possible representations in various approaches.

For Schane, who refers to his single-valued features as **particles**, each step down the vowel-height scale involves the addition of **a**, so that a low vowel contains more than one occurrence:

(99)	/i/	/e/	/ɛ/	/a/
	i	**ia**	**iaa**	**iaaa**

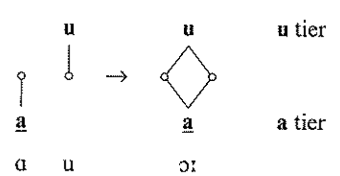
Dependency-based theories adopt a different approach. In these theories, the difference between pairs of mid vowels in a scalar system is achieved by allowing one of the features to contribute more to the segment than the other. The features which are required in the representations of /o/ and /ɔ/, say, are identical (**u** and **a**), but **u** is more 'important' in the representation of /o/ than **a**, while for /ɔ/ the roles are reversed. In other words, one feature is the **head** and the other the **dependent**. We give the representations for a typical seven-vowel system lacking front rounded vowels in (100), where we indicate the head in any representation by underlining.[30]

(100)	/i/	/e/	/ɛ/	/ɑ/	/ɔ/	/o/	/u/	
	i	$\underline{\text{i}}$	i		u	$\underline{\text{u}}$	u	**i**/**u** tier
		a	$\underline{\text{a}}$	a	$\underline{\text{a}}$	a		a tier

Within this approach, scalar processes such as lowering and raising can be characterised as changes in the relationships between the features on the two tiers, such that, as we move along a scale, one feature becomes more 'important' in the representation of the segment than another. Thus, the scale from /ɑ/ to /u/ is characterised as an interaction between the two features **a** and **u**, whereby **a** is initially maximally prominent in the representation (it is the only feature for /ɑ/) and ultimately minimally prominent (it is absent for /u/).

The introduction of dependency allows us to refine our analysis of the monophthongisation process in (48). There we saw that the monophthongisation of /ɑu/ to /ɔː/ involved simply the rearrangement of features. Now, anticipating our discussion of suprasegmental structure in Chapter 3, we can show why the expected outcome of the monophthongisation is indeed /ɔː/, rather than /oː/, which also contains the features **u** and **a**. For /ɔː/, the head is **a**, while for /oː/ it is **u**. The output /ɔː/ is therefore expected, as /ɑu/ is a 'falling' diphthong, in which the first element is more prominent than the second, and therefore can be interpreted as the head, as in (101):

(101)



[30] Headship is denoted in various ways in the literature on dependency relations in phonology. In the approach known as **dependency phonology** (Anderson and Jones 1974, 1977; Ewen 1980a; Anderson and Ewen 1987), heads are placed higher in the segmental representation than their dependents. This formalisation is difficult to combine with autosegmental representations incorporating tiers, so we adopt here the underlining convention of, e.g., Harris (1994: §3.3.3).

The dependency relation can also be invoked to provide a more satisfactory relationship between the representations of the tense (peripheral) and lax (central) vowels in (98), where the lax vowels were characterised as containing an extra feature @ in comparison with their tense counterparts. Thus a change from /i/ to /ɪ/, say, could involve the addition of a feature. It is not immediately obvious that it is appropriate to treat central vowels as containing more features than peripheral ones, and this leads Harris (1994) to suggest that all vowels, both 'tense' and 'lax', contain @, with @ being the head in the representation of a lax vowel, and a dependent otherwise, as in (102):[31]

(102)	/i/	/e/	/ɑ/	/o/	/u/	/ɪ/	/ɛ/	/ə/	/ɔ/	/ʊ/	
	$\underline{\text{i}}$	$\underline{\text{i}}$				i	i				i tier
		a	$\underline{\text{a}}$	a			a	a	a		a tier
				$\underline{\text{u}}$	$\underline{\text{u}}$				u	u	u tier
	@	@	@	@	@	$\underline{@}$	$\underline{@}$	$\underline{@}$	$\underline{@}$	$\underline{@}$	@ tier

Furthermore, Harris claims that @ only contributes to the interpretation of a segment if it is a head; in dependent position it has no interpretation.

2.6 Consonants and single-valued features

A claim that has often been made in support of Single-valued Feature Theory is that it provides a simple metric for measuring the inherent complexity of a segment: the more features a segment requires in its specification, the more complex it is. Thus the 'pure' vowels /i u ɑ/, each characterised by a single feature, are less complex than 'mixed' vowels such as /e o y ø/, which require two or three features. We do not pursue this here with respect to vowel features, but we will examine briefly how the notion has been utilised in accounting for lenition processes such as those considered in §1.3.1. We saw there that intervocalic lenition involves movement along what seemed to be a sonority-based hierarchy, such that a voiceless stop might first pass through a voiced stop or voiceless fricative stage, then a voiced fricative stage, on its way to a sonorant consonant. Each stage has been typically viewed as assimilation in some property to the surrounding vowels; indeed, the sonorant consonant often vocalises in this context. At first sight, then, we might expect lenition to be characterised in terms of spreading from the surrounding vowels. However, it has often been observed that lenition ultimately leads to deletion; indeed, an often quoted definition is that of Hyman (1975: 165):

(103) A segment X is said to be weaker than a segment Y if Y goes through an X stage on its way to zero.

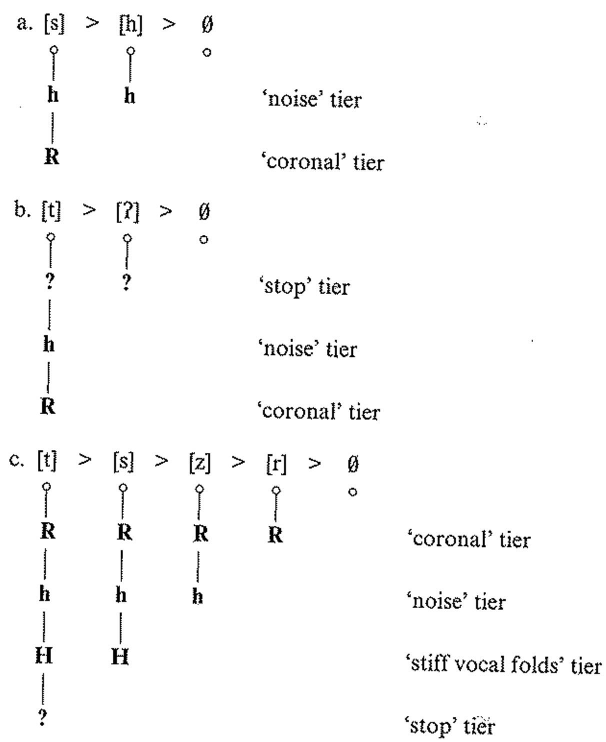
[31] For the sake of exposition, we treat **i** and **u** as the head of /e/ and /o/, respectively. A full account would have to consider the relationship between these features and **a**, however.

This fact has been utilised in treatments of lenition as involving reduction in complexity of a segment, such as that of Harris (1990, 1994). Harris notes that lenition as defined in (103) is not restricted to intervocalic position, but is also found in initial and final position. In initial position we find developments such as that in (104a), and in final position (104b), as well as the intervocalic 'trajectories' in (104c, d):

(104) a. (voiceless) fricative > [h] > ∅
b. (voiceless) plosive > [ʔ] > ∅
c. voiceless plosive > voiceless fricative > voiced fricative > liquid > ∅
d. voiceless plosive > voiced plosive > voiced fricative > liquid > ∅

In Harris's terms, each of these changes must involve the removal of a feature from the representation. This in turn means that segments at the consonantal end of the sonority hierarchy have maximally complex feature representations; those at the vocalic end have minimally complex representations. It would take us too far here to examine the full set of features which Harris proposes; we restrict our account to showing in (105) some examples of lenition in the model which he proposes:

(105)



The set of features which Harris employs certainly allows a uniform treatment of the various processes in (104) as involving reduction in the number of features. However, the resulting representations of consonants seem to be at odds with a single-valued feature system which characterises the vowel space in terms of the three features **i**, **u** and **a**. These features were claimed to be appropriate because they correspond in isolation to the most basic vowels, those at the 'corners' of the vowel triangle. With respect to the sonority hierarchy, it would seem that the two extremes of the hierarchy, voiceless stops and vowels, should have the same status as these basic vowels. However, it follows from Harris's model that voiceless stops must have the most complex representation, which is in conflict with this claim.[32]

The claim that voiceless stops and vowels are the maximally simple categories obviously means that intermediate categories are more complex, in the same way that mid back vowels are more complex than /u/ or /ɑ/. On this assumption, lenition cannot be interpreted as involving an across-the-board decrease in complexity (or, indeed, an increase in complexity). Indeed, we believe that it is mistaken to equate lenition and complexity, either inversely or directly, and that this results from the assumption that all the lenition processes in (104) have the same cause. Those in (104a) and (b) are indeed cases of reduction of complexity, as we suggested in our characterisation of [h] in §1.3.5 as a 'defective' segment, lacking a place specification of its own. The same account would be appropriate for [ʔ]. However, as we have noted, intervocalic changes seem to be triggered by assimilation to some property of the surrounding vowels; there seems to be no *a priori* reason to expect that spreading should lead to reduction in complexity. Indeed, in a single-valued approach, we would expect the reverse, if anything.

How, then, might we represent the assimilation involved in intervocalic lenition within a single-valued model? Notice that lenition in these terms does not involve place of articulation, and so we assume that features such as Harris's **R** (coronality) play no role. Rather, the features involved are those corresponding to the binary features dominated by the **categorial** class node in (43) in Chapter 1, i.e. [sonorant], [consonantal], [continuant] and [voice] (cf. our discussion in §1.3.5).

Earlier in this chapter we introduced, but did not discuss, the single-valued features **C** and **V**, which may be taken as corresponding to [+consonantal] and [+sonorant], respectively. By analogy with the interpretation of single-valued vowel features when they occur alone, these two features in isolation

[32] It is interesting to notice that other models (e.g. that of K. D. Rice 1992) incorporate a system of representation in which complexity *increases* as a segment becomes more sonorous.

are interpretable as the extremes of the 'categorial space', i.e. as stops and vowels, respectively. Other categories of segments, e.g. fricatives and sonorant consonants, can be represented as various combinations of the two features, as in (106), where we take the coronal series as examples:

(106)	/t d/	/s z/	/l r n/	/i/	
	C	**<u>C</u>**	**C**		C tier
		V	**<u>V</u>**	**V**	V tier

As before, we introduce the dependency relation into the representations; as we would expect, in the representation for sonorant consonants **V** is more prominent than for fricatives. As in the case of vowels, as we move from one end of the hierarchy to the other, one feature becomes more 'important', at the expense of the other. In a model like this, we can characterise weakening as an increase in the prominence of **V**, i.e. as an assimilation to the **V** feature of the surrounding vowels.

Clearly, as we have presented it, the model only defines a few of the categories on the sonority scale. As in our presentation of Harris's model of consonantal features, we will not consider the way in which this model deals with the full range of possibilities, especially as there is an extensive literature within dependency phonology which deals with this issue (although this generally adopts a rather different notation).[33]

2.7 Laryngeal features

Up to this point we have been assuming that the feature [voice] is adequate for the characterisation of what are often referred to as laryngeal oppositions. In a binary approach, segments have been considered to be either [+voice] or [–voice]. In a model incorporating underspecification, a segment may bear no value for [voice], as in our account in §2.2.3 of voicing assimilation in Russian. If this feature is appropriate, it is obviously relevant for single-valued theory to establish which value is 'active' in languages; i.e. whether it is [+voice] or [–voice] which is typically involved in spreading, for example. However, even within binary theory, it has long been recognised that a simple binary feature is inadequate to express the full range of laryngeal oppositions which are found in languages. Indeed, Halle and Stevens (1971) propose replacing [voice] by no fewer than four binary features, [spread glottis], [constricted glottis], [slack vocal folds] and [stiff vocal folds]. However, as Ladefoged (1973) points out, these four features in fact characterise

[33] See for example Anderson and Ewen (1987: §4.4), Ewen (1995: §2.2), van der Hulst (1995).

two ternary parameters, in the same way as the binary features [high] and [low] are the expression of the single parameter of vowel height.

Consider first the parameter spread/constricted glottis. This parameter characterises the degree of glottal opening, independent of whether the vocal folds are in vibration. A feature is required for this parameter to represent the opposition which some languages display between different types of voiced or voiceless segments, as in (107) (data from Ladefoged 1973: 80):

(107)		[–spread, +constr]	[–spread, –constr]	[+spread, –constr]
a.	*Hausa*	b̰	b	
b.	*Uduk*		p	pʰ
c.	*Beja*	d̰	d	d̤
d.	*Sindhi*		b	b̤

The various types of contrasts in (107) are appropriately characterised in terms of glottal opening, i.e. between laryngealised (creaky voiced) and 'normal' voiced plosives in Hausa (107a), between 'normal' voiced and breathy voiced plosives in Sindhi (d) and between voiceless unaspirated and voiceless aspirated plosives in Uduk (b). The contrast in Beja in (107c) involves a three-way opposition between different types of voiced plosives, viz. creaky voiced, 'normally' voiced and breathy voiced.

In terms of laryngeal oppositions, the second parameter, stiff/slack vocal folds, is responsible for the difference between the presence and absence of vocal fold vibration: voiced sounds are [+slack vocal folds], voiceless sounds [+stiff vocal folds]. Lenis sounds, however, are neither slack nor stiff, so that Korean has the opposition in (108d):

(108)		[–stiff, +slack]	[–stiff, –slack]	[+stiff, –slack]
a.	*Hausa*	b̰/b		p
b.	*Uduk*	b		p/pʰ
c.	*Beja*	d̰/d/d̤		t
d.	*Korean*		d̥	t/tʰ

One of the reasons for claiming that three oppositions are required here is that there appears to be a close relationship between vocal fold vibration and tone. It is claimed that [+slack] corresponds to low tone, and [+stiff] to high tone, while a mid tone corresponds to a lenis unvoiced consonant. This is not an issue which we will pursue here, except to note that, although the evidence for having distinct features for glottal opening and vocal fold vibration is convincing, it is not entirely clear that we require a three-way opposition for the vocal fold vibration parameter; as Ladefoged (1973: 82) points out, we have no simple way of specifying the difference between voiced and voiceless sounds.[34] Moreover, it appears that the feature combinations in (107) and (108) can describe a much larger set of laryngeal oppositions than is ever found in languages.

2.7.1 *Single-valued laryngeal features*

Within single-valued theory, it has been generally assumed that a feature corresponding to [voice] is not in itself sufficient for the characterisation of laryngeal contrasts. Nevertheless, something corresponding to [voice] is usually incorporated, so that we now need to address the question raised in the previous section: is [+voice] or [–voice] the active value?

Harris (1994: §3.6) cites evidence which appears to show that languages differ in this respect, even though, unlike the languages in (107) and (108), they only have a two-way laryngeal opposition. In English, he observes, the 'voiced stop' series /b d g/ is in fact very rarely voiced, but is often phonetically voiceless and lenis. The /p t k/ series, on the other hand, is always voiceless, and in initial position is aspirated. Furthermore, some property of the voiceless series seems to be 'active' in English, as evidenced by the devoicing of a following liquid:

(109)	/krɪb/	[kɹ̥ɪb̥]	crib
	/pli:z/	[pl̥i:z̥]	please

(we also indicate the devoiced nature of the final 'voiced' obstruents).

In French, however, Harris observes that the series /b d g/ is always fully voiced, and the /p t k/ series unaspirated, and suggests that this means that in French /p t k/ is the 'neutral' series, while in English it is /b d g/ – the two series are, he observes, 'to all intents and purposes [phonetically] identical'. In this connection, it is instructive to consider again the Dutch data in (24), where we analysed the realisation of *zakdoek* /zɑkduk/ 'handkerchief' as [zɑgduk] as involving spreading of [+voice]. Notice that Dutch, like French, does not aspirate the voiceless series.

These facts lead Harris to propose two single-valued features, one corresponding to [+slack vocal folds], **L**, and one to [+stiff vocal folds], **H** (the choice of symbols reflects the relationship with tones discussed above). There is no feature corresponding to the parameter of glottal opening, but Harris observes of **H** that 'aspiration is the particular interpretation this [feature] receives when it is present in an expression defining a fortis plosive'. (Aspiration

[34] Indeed, Ladefoged casts doubt on a number of the phonetic claims supporting the [stiff vocal folds] feature.

is associated with a fully open glottis.) Most languages will only require one of these features, the choice between which will depend on which is active in the phonology of the language in question. In English, **H** is active, so that the voiceless series contains an extra feature in comparison with the 'neutral' lenis series, while in French and Dutch **L** is active, and the voiceless series is 'neutral':

(110)	a. *English*		b. *French*		c. *Dutch*			
	/p t k/	/b d g/	/p t k/	/b d g/	/p t k/	/b d/		
	H						**H** tier	
				L		**L**	**L** tier	
	cool	ghoul	peau	beau	tuin	duin		
			'skin'	'beautiful'	'garden'	'dune'		

Languages with more than a simple two-way opposition utilise both features, and indeed both may appear in the representation of a single segment (data from Harris 1994: 135):

(111)	a. *Thai*				
	/p^h/	/p/	/b/		
	H				**H** tier
			L		**L** tier
	/p^{h}àa/	/pàa/	/bàa/		
	'split'	'forest'	'shoulder'		
	b. *Gujarati*				
	/p^h/	/p/	/b/	/b̤/	
	H			**H**	**H** tier
			L	**L**	**L** tier
	/p^{h}ɔdz/	/pɔɾ/	/baɾ/	/b̤aɾ/	
	'army'	'last year'	'twelve'	'burden'	

Although this approach gives a perspicuous account of the way in which different languages deal with laryngeal contrasts, the actual choice of features raises some questions. It is difficult to see that **L** and **H** represent *distinct* phonetic parameters; both their articulatory definition (slack vs stiff vocal folds) and what Harris calls their 'signal mapping' (low vs high fundamental frequency) appear to suggest that a single parameter is involved. This in turn would imply that the opposition is an equipollent one, contrary to the fundamental claim of Single-valued Feature Theory.

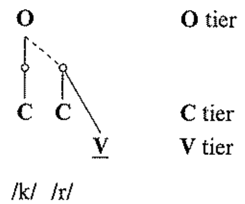
We think that this problem can be avoided by abandoning **H**, and replacing it by a feature of glottal opening, which we label **O**.[35] Notice that this allows us to characterise laryngeal contrasts in terms of two distinct parameters, and

[35] For earlier proposals along these lines, see Ewen (1980b); Anderson and Ewen (1987: §5.1).

also to give up [stiff vocal folds] as an active value, which seems desirable on phonetic grounds (cf. again Ladefoged 1973). However, the representations in (110) and (111) need not change, except for the substitution of **H** by **O**.

Consider now the analysis of the English 'devoicing' processes in (109). English, as we have seen, has **O** as an active feature. The fortis stop series contains **O**, which will be realised as aspiration in syllable-initial prevocalic position. However, when a fortis stop is followed by a liquid, spreading of **O** takes place, as in (112):

(112)



The representation of the sonorant which results from the spreading of **O** is such that the specification for glottal opening overrides the inherent voicing of the sonorant; spread glottis in English is incompatible with vocal fold vibration. It is interesting to notice that voiceless sonorants tend to occur only in those languages in which **O** is the active feature; Dutch, for example, in which the voiceless stop series is 'neutral', does not display devoicing of this sort.

2.8 Summary

Chapter 1 was concerned with the way in which features characterise segments. In this chapter we have been focusing on the nature of the features themselves, in particular on the question of how many of the phonetic properties of segments should be encoded in phonological structure. In §2.1 we examined the claim that features should characterise binary oppositions rather than gradual oppositions, and that the most natural way of representing such opposition is in terms of binary features. We considered evidence which appeared to challenge the idea that both the presence and the absence of a phonetic property is *necessarily* encoded in terms of the two opposing values of a binary feature. One such piece of evidence involved the properties of nasality and orality. We argued that the property of orality does not have to be encoded in any other way than in terms of the absence of nasality. In other words, orality is not a 'positive' property, and we therefore require no explicit means of characterising it, e.g. as the absence of nasality. We suggested that the feature characterising the oral–nasal dimension can therefore be considered to be single-valued.

The asymmetry between the two poles of phonetic dimensions has received different formal treatments in the phonological literature, some of which maintain the hypothesis that all phonological features are binary. These we considered in §2.2, in particular with reference to approaches incorporating the concepts of redundancy and underspecification. In §2.3 we considered feature asymmetry in terms of single-valued feature theories, our focus being on the characterisation of vowel structure, and in §2.4 we demonstrated how the various theories considered in §§2.2 and 2.3 dealt with the analysis of a number of umlaut and harmony processes.

§2.5 saw the introduction of a further concept in the representation of the segment: dependency. Dependency is a relation holding between features in a segmental representation, such that a feature may occupy a head position or a dependent position. We demonstrated how this concept can be used in the representations of vowels, while §2.6 was concerned with how single-valued features and, to a lesser extent, dependency can be used in the characterisation of consonantal structure, in particular with respect to their major class and manner properties. Finally, in §2.7 we applied the same notions to the representation of laryngeal properties.

2.9 Further reading

Much of the further reading mentioned in §1.6 is also relevant to this chapter.

On the nature of phonological features (§2.1), see Trubetzkoy (1939: ch. 3) for the fundamental notions of the 'logical classification of distinctive oppositions'. See Anderson (1985: ch. 4) for discussion. On multivalued features, see Ladefoged (1971), Vennemann and Ladefoged (1973) and Williamson (1977). Clements (1985) and McCarthy (1988) are basic references for feature geometry. See also Padgett (1995), and, on the different types of features and tiers in feature geometry, Avery and Rice (1989).

There is a substantial body of literature on the various theories dealt with under the heading 'feature asymmetry' (§2.2). Chomsky and Halle (1968: ch. 9) lay out their theory of the 'intrinsic content of features'. Cairns and Feinstein (1982) and Cairns (1988) propose refinements on the markedness theory of *SPE*. For critical accounts of markedness theory, see Lass (1975), Lass and Anderson (1975: App. IV) and Kean (1980).

Steriade (1995) provides an overview of the issues involved in markedness and underspecification (§2.2.1). For early arguments against allowing binary features to be unspecified (§2.2.2), see Stanley (1967). For work on contrastive specification (§2.2.3) and radical underspecification (§2.2.4), see Kiparsky (1982), Archangeli (1984, 1988a), Pulleyblank (1988a, b), Ringen (1988), Abaglo and Archangeli (1989), Mester and Itô (1989), Mohanan (1991), Archangeli and Pulleyblank (1994), Pulleyblank (1995). Itô *et al.* (1995) consider the role of underspecification in Optimality Theory. Keating (1988b) shows the relevance of underspecification in phonetic representation. See also Stevens *et al.* (1986), Stevens and Keyser (1989).

Much has been written on single-valued vowel features, and on the notion that the vowel space is triangular (§2.3). See for example Sanders (1972), Anderson and Jones (1974), Schane (1984), Goldsmith (1985), Rennison (1986, 1990), Anderson and Ewen (1987), Kaye *et al.* (1990), Harris (1994), Harris and Lindsey (1995), Lombardi (1996) and Cyran (1997).

For reading on umlaut and harmony processes (§§2.4, 2.4.1), see the papers in Vago (1980) and van der Hulst and Smith (1988a), as well as Aoki (1968), Anderson (1973), Ultan (1973), Vago (1973), Ringen (1975), Halle and Vergnaud (1981), Hume (1990), van der Hulst and van de Weijer (1995) and Polgárdi (1998).

For accounts of Yawelmani harmony (§2.4.2), see Kuroda (1967). Archangeli (1984), Pulleyblank (1988a) and Archangeli and Pulleyblank (1989, 1994) give accounts of harmony in Yoruba (§2.4.3). For a discussion of harmony in Nez Perce, in particular whether it involves spreading of ATR or of **a**, see Anderson and Durand (1988).

The notion of segment-internal headedness (§2.5) originates in the model of dependency phonology (Anderson and Jones 1974; Ewen 1980a; Anderson and Ewen 1987; van der Hulst 1989). See Lass (1984a: ch. 11) for an overview. Essentially the same concept is employed in government phonology (Kaye *et al.* 1985, 1990; Harris 1994). The term 'dependency' is used in different senses elsewhere, particularly in feature geometry; see e.g. McCarthy (1988), Mester (1988) and Piggott (1992). For an overview of dependency in phonology, see Ewen (1995).

For proposals on the representation of consonants in single-valued feature theory (§2.6), see, besides the dependency and government references given above, Smith (1988), Harris (1990, 1997) and Harris and Kaye (1990). Ladefoged (1975: ch. 12) offers an account in terms of a multivalued feature [place], whose values correspond to the traditional articulatory labels for place of articulation.

For binary treatments of the representation of laryngeal features (§2.7), see Halle and Stevens (1971), Ladefoged (1973), Iverson (1983), Lombardi (1991) and Steriade (1996). For analyses in terms of single-valued features, see Ewen (1980b), Davenport and Staun (1986) and Harris (1994).

3 Syllables

3.1 Introduction

In the first two chapters of this book we considered the internal structure of the segment in some detail. In the course of our discussion, we saw that certain features may be relevant to stretches of speech larger than just a single segment. This generally involved cases where two adjacent segments agreed in their specifications for place or voicing, for example. In other cases, such as vowel harmony, the two segments involved appeared not to be immediately adjacent, in that consonants could intervene which did not appear to be affected by the harmony process in question. However, we argued that the adjacency condition was in fact met, provided that we interpreted adjacency to refer to successive elements on some tier.

There are still other types of cases in which stretches of adjacent segments appear to agree with respect to a certain property. For example, in the South American Indian language Terena (or Tereno), spoken in Brazil (cf. Bendor-Samuel 1960), the 1st person singular morpheme is realised by spreading nasality from left to right throughout the word. Thus the form for 'his brother' is [ɑjo], while the form for 'my brother' differs only in the fact that all the segments are nasalised, giving [ɑ̃j̃õ]. In the kind of notation we have been developing (ignoring considerations of underspecification, etc.), we can show that sequences of segments can share a single nasal feature or autosegment as shown in (1) (we are assuming that nasality is expressed by a single-valued feature **N** (cf. §2.3); we also use the single-valued features **V** and **C**):

(1) **N**   **N** tier

V **C** **V**

ɑ j o   [ɑ̃j̃õ]

In cases like this, a single feature appears to be the property of a sequence of segments, rather than of an individual segment. This raises the question