ASPECTS OF PHONOLOGICAL STRUCTURE
WITH PARTICULAR REFERENCE
TO ENGLISH AND DUTCH

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Abstract

This thesis is concerned with establishing the notational system of dependency phonology, first developed by Anderson and Jones (1974a, 1977), as a framework for the characterisation of phonological structures and systems in languages of the world. As such, it is offered as an alternative to other phonological frameworks that have been proposed, notably models based on the concept of the distinctive feature, such as those of Jakobson et al (1952), Chomsky and Halle (1968), and Ladefoged (1971).

Chapter 1 deals with what it is that a notational system should be able to characterise - i.e., what properties such a system should have - while in chapters 2 and 3 I examine various notational systems which have been proposed. In chapter 4 the formal properties of the dependency model are developed and illustrated, and in chapter 5 I make various proposals as to how the phonological segment should be divided into sub-matrices, or 'gestures'. On the basis of this, I investigate in detail in chapters 6, 8, and 9 the nature of each of these gestures - the categorial, the articulatory, and the initiatory - and offer a set of dependency components, whose function is to represent the various aspects of the segment characterised by the three gestures. In chapter 7 I depart from the characterisation of the segment to look at the structure of sequences in the light of the representations of the categorial gesture set up in chapter 6, and devote some space to a discussion of the representation of 'complex segments' and related issues. Finally, I consider two large scale phonological processes in terms of dependency phonology - initial mutation in Welsh, and diminutive formation in Dutch.
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Chapter 1

Notational Systems 1: Introduction

In what follows, I shall be concerned with developing a theory of phonological structure, the theory of dependency phonology. To date, various publications have appeared in which the theory has been introduced, and to some extent developed, viz. Anderson and Jones (1974a, 1977), Anderson (1980), Ewen (1977, 1978, forthcoming a, forthcoming b), but as yet there has been no attempt to develop a fully worked out theory of phonological structure within the dependency model. It is the aim of this thesis to show how this might be done; i.e. to indicate how a fully developed model of dependency phonology might replace other systems of phonological notation currently in use, notably distinctive feature systems such as that of The Sound Pattern of English (Chomsky and Halle 1968; henceforth SPE).

The discussion falls into various parts. In the remainder of this introduction, I examine the requirements of a theory of phonological notation, i.e. the kinds of phenomena for which such a theory should be able to account. Thereafter, various other proposed notational systems are examined, and the deficiencies of these are discussed. In chapter 4, the basic tenets of the theory of dependency phonology proposed by Anderson and Jones are examined, and the model is further developed in chapters 5-9. Finally, I consider in depth two 'phonological problems' - i.e. areas of the phonologies of particular languages which present problems relevant to notational systems, and consider how they may be tackled within the notational system established in the preceding chapters.

In general, however, I will not be concerned with specifying the rules of any particular language. Rather, as the aim is to work
out a system of representation which is, in principle, universally adequate, exemplification will be drawn in the main from familiar areas of difficulty for phonological analysis. Much of the data will be from English and Dutch - both from the modern languages and their dialects and from their histories - as these are the languages with whose phonologies I happen to be most familiar. However, I will not hesitate, where appropriate, to consider data from other languages.

It will perhaps be useful, before going on to consider various systems of phonological notation, to examine what is understood here by terms such as 'phonological structure' and 'phonological notation'.

1.1 Phonological structure

We may distinguish two aspects of phonological structure - the structure of segments, and the structure of sequences.

As far as the structure of segments is concerned, theories of phonological notation may differ from each other in being either 'componential' or 'non-componential'. In componential theories, the segment is considered to have some degree of internal structure, while in non-componential theories this is not the case. In the latter, the segment is treated as an indivisible entity, represented by a single unanalysable symbol such as /l/, /w/, /ʃ/, /θ/, etc. Theories in which the segment is considered to have some internal structure may have various forms, and as many of the following chapters are concerned with such variations, I shall not anticipate the discussion here. However, we may illustrate perhaps the most common system currently in use, that found in *SPEC*, with (1.1):
In the SPE system, the segment is considered to consist of an unordered set of ordered pairs (cf. Sommerstein 1977:94). Each pair consists of a value ('+' or '-'), and the feature-name. The exact nature of the individual features need not concern us at present. A notational system which is componential allows us to show that particular sets of segments have certain phonological properties in common (e.g. in the SPE system /k/, /ʃ/, /f/ would share the feature-value [-voice], while /e/, /o/, /ʊ/ would share the values [+syllabic, -high, -low], among others).

The notion of structure in sequences, again, may or may not be represented in systems of phonological notation. In a notational system without segmental or sequential structure, the English word <mandarin> might be given the representation in (1.2) (for an RP pronunciation):

(1.2) /mændərɪn/

i.e. a representation in which the segments are presented in linear sequence only. Notational systems in which sequential structure is invoked, however, might, for example, involve the assignment of segments to syllables, as in (1.3):

(1.3) [mæn[d]ə][rɪn]

\[ \begin{array}{ccc}
1 & 2 & 3 \\
\end{array} \]
where the particular syllable bracketing is based on the syllable overlap theory of Anderson and Jones (1974a, 1977) - see also Anderson (1973, 1975, 1977), Durand (1976), Jones (1973, 1976, 1977), and for further discussion, chapter 6, where I also consider in more detail the theory of sequential structure in dependency phonology.

Alternatively, or additionally, phonological sequences may be assigned some kind of hierarchical structure. Thus, for example, within the version of 'metrical phonology' proposed by Selkirk (ms), sequences of segments are considered to constitute various 'prosodic categories', as in (1.4):

\[(1.4)\]

\[
\begin{array}{c}
\sigma \\
\Sigma \\
\Sigma' \\
\omega \\
\end{array}
\]

where \(\sigma\) = syllable, \(\Sigma\) = foot, \(\Sigma'\) = super-foot, \(\omega\) = prosodic word, and \(s\) and \(w\) denote respectively 'strong' and 'weak'. I return in §3.5 to a discussion of the motivation for structures like (1.4) and their internal organisation; what is relevant here is the postulation of hierarchical structures associated with sequences.

There are thus two issues; firstly, what degree of phonological structure in segments and sequences is appropriate, and, secondly, what is the most appropriate notation for the representation of the desired structures? The first of these points will be discussed in the following sections, while the second forms the bulk of the remainder of the thesis.

1.2 Notational models vs. 'phonological theories'

It is important to distinguish the kinds of considerations outlined in the previous section from the question of the kind of 'phonological theory' which may be appropriate for phonological
In the past decade or so, the theory of generative phonology, developed in SPE and elsewhere, has been seen as the 'standard' phonological theory. Partly, no doubt, as a result of the fact that the feature system proposed in SPE has also been adopted as the standard system of phonological notation, there has been a tendency to consider these two aspects - the theory of generative phonology, and the system of distinctive features found in SPE - to be in some way inseparable; i.e. it has been assumed that acceptance or rejection of the one necessarily implies acceptance or rejection of the other.

However, it is clearly not the case that the two aspects are completely interdependent. The theory of generative phonology, with its various concepts such as underlying forms, phonological rules, systematic phonetic and phonemic levels, etc., is not dependent on being expressed in terms of distinctive features. Indeed, in most works on generative phonology, a notational system in which segments are represented as having no internal structure is used in the presentation of, for example, derivations of particular surface forms (albeit as a non-systematic abbreviation for distinctive feature specifications). Consider, for example, the derivations of the singular and plural forms of the Dutch word <hoofd> 'head' in certain dialectal realisations (van Bakel 1976:71):

(1.5) grondvormen: [ho. fd] [ho.fde]

regel (68) [ho.ft] [ho.fde]
regel (64) [ho.ft] [ho.vde]
regel (85) [ho.f] [ho.vde]

(where the derivations and the rules proposed by van Bakel are not relevant here). Thus, the processes of generative phonology might (at least informally) be represented in terms of a non-componential notational system. However, more importantly, they might also be characterised in terms of various other componential systems, whether based on the distinctive feature or not, such as those to be discussed in chapters 3 and 4.
Similarly, it is possible to envisage the use of various componential notational systems with other types of phonological theories, such as the Prague School theory of, for example, Trubetzkoy (1939) and Jakobson (1941). In addition, the validity of the more recent theory of natural generative phonology, associated with Vennemann and Hooper (see, for example, Vennemann 1972, Hooper 1976), in which the very abstract underlying forms found in SPE are rejected, is also independent of the notational system employed. The argument, then, as to whether the surface form of Eng. <ice> (RP) [aɪs] should be derived from an underlying abstract form such as /i:s/ is in principle independent of the notational system used to represent these phonological (or phonetic) claims.

It would, however, be misleading to deny that notational systems and phonological theories interact with each other in fairly intricate ways, or that the choice of a particular notational system might preclude the development of certain phonological theories. For example, the choice of a non-componential system would preclude, or at least render less perspicuous, many of the generalisations expressed by generative phonology. Thus, Kean (1980:49-50) argues that in a theory of phonology without distinctive features (1.6) is, with respect to the 'evaluation measure' (which measures the 'cost' of a rule to the grammar), less highly valued than (1.7), in that (1.7) is 'simpler':

(1.6) \( \{ \{ k \} \rightarrow \{ \hat{c} \} / \{ l \} \) \\
(1.7) \( q \rightarrow l / \{ f \) \\

However, if (1.6) and (1.7) are rewritten in terms of distinctive features, as (1.8) and (1.9) respectively, (1.8) appears more simple, and hence more highly valued, than (1.9); as (1.8) represents "a fairly common phonological rule" and (1.9) a "quite inconceivable" process, this is the appropriate state of affairs:
This leads Kean to conclude that "in generative phonology the set of notational devices and the classificatory features are central to the evaluation measure - that is, the measure makes no sense in a theory of phonology which has neither features nor notational devices". This, however, seems to be too strong a claim. At most it can be claimed that the evaluation measure "makes no sense" in a non-componential notational system; it is not impossible to conceive of a notational system not using the distinctive feature in which componentiality could be retained and the notion of the evaluation measure incorporated.

Similarly, while the motivations for postulating an underlying form /iːs/ in English may not be directly related to the issue of notation, it is nevertheless true that the use of a non-componential system would make it very difficult to formulate the change from /iːs/ to [æːs] in such a way as to characterise the process as an example of a set of related processes - the 'vowel shift' processes in the Chomsky and Halle generative model.

The vowel shift processes (reflexes of the operation of the Great Vowel Shift in the history of English) must, Chomsky and Halle claim, be able to capture the relationship between each of the abstract forms and its corresponding surface form in (1.10) as being in some sense the same:

\[
\begin{align*}
\text{(1.8)} & \quad \left[ +\text{cons} \right] \rightarrow \left[ +\text{cor} \right] \\
& \quad \left[ +\text{DR} \right] \\
& \quad \left[ +\text{stri} \right] \\
& \quad \left[ +\text{high} \right] \\
& \quad \left[ -\text{cons} \right] \\
& \quad \left[ -\text{back} \right] \\
\text{(1.9)} & \quad \left[ +\text{cons} \right] \\
& \quad \left[ +\text{low} \right] \\
& \quad \left[ +\text{lat} \right] \\
& \quad \left[ -\text{son} \right] \\
& \quad \left[ +\text{cont} \right] \\
& \quad \left[ +\text{lab} \right] \\
\end{align*}
\]
It would be difficult to envisage any way of stating this generalisation in a non-componential framework, while the SPE notational system allows the relationships of (1.10) to be stated "in a very simple way" (SPE:53), as (1.11) (from SPE:187):

\[
\begin{align*}
(1.10) & \quad \text{abstract} \quad \text{surface (RP)} \\
/l:i:s/ & \quad [ais] \quad <\text{ice}> \\
/tei:k/ & \quad [teik] \quad <\text{take}> \\
/kwein/ & \quad [kwi:n] \quad <\text{queen}>
\end{align*}
\]

(1.11) \[
\begin{align*}
\begin{cases}
[-\text{high}] / [\text{ahigh}, -\text{low}] \\
[+\text{tense}] \\
[-\text{low}] / [\text{blow}, -\text{high}] 
\end{cases}
\end{align*}
\]

\( (\text{Part (a) of the rule states that a tense vowel which is } [-\text{low}] \text{ changes its value for the feature } [\text{high}], \text{ and part (b) that a } [-\text{high}, +\text{tense}] \text{ vowel changes its value for the feature } [\text{low}]. \text{ The two parts of the rule are conjunctively ordered; thus the vowel of } <\text{ice}> \text{ first undergoes part (a)} (/\text{Tys}/ (=/l:i:s/) \rightarrow [\text{\text{\~y}}\text{s}] (= [\text{ais}]) ), \text{ then part (b)} ([\text{\text{\~y}}\text{s}] \rightarrow [\text{\text{\~y}}\text{s}] (= [\text{ais}] ) \text{ -- note that the symbols which Chomsky and Halle use are not those traditionally used to transcribe RP.})
\]

The generative phonologist would argue that the claims embodied in (1.10) about the synchronic phonology of English can only be successfully characterised by a notational system such as that of SPE. Nevertheless, I believe that the arguments which must be developed in defence of a particular notational system should not rest on its appropriateness for the expression of the concepts of a particular phonological theory. Rather, I assume that there are phonological regularities which have to be expressed by any theory - that is, we can accept that there are certain well-attested types of phonological processes which are available for inspection, specifically, processes which recur in the histories of languages of the world, and that it is this kind of evidence which must be used in evaluating a system of notation, rather than evidence from the constructs of a particular.
theory. The relationships in (1.10), then, would not be an example of such a process, in that there is no general acceptance of the view that they form part of the synchronic phonology of English. (This is not, of course, to deny the existence of recurrent vowel shift processes in the histories of languages; however, the 'simple' set of relationships apparent in (1.10) would not be relevant in a historical description of English - see, for discussion, Lass 1976: ch. 2, Wolfe 1972).

In the chapters which follow, then, I shall be concerned only with the adequacy of notational systems, not of phonological theories. Although we shall see that the SPE distinctive feature system does not appear to meet the requirements of a notational model outlined in the remainder of this chapter, this does not imply that the theory of generative phonology must also be considered to be inadequate. In fact, I shall not commit myself either to the acceptance or to the rejection of any particular phonological theory. Rather, I shall assume that any notational system should be adequate to characterise any well motivated, and generally accepted, phonological analysis, whether it be an analysis in terms of generative phonology, natural generative phonology, classical phonemic theory, or whatever. In adopting this view, I suggest that in cases where theories are developed which contain rules, generalisations, etc. which do not conform to publicly accepted notions of phonological 'naturalness' and similar concepts, and which existing notational systems are unable to represent, the onus is on the proponents of such theories to show that there is indeed motivation for the adoption of such a new theory, together with the necessary adaptation of the notational system.

It will be seen, then, that my main concern is with a model of phonological structure - i.e. a representation of the segments and sequences which occur in the phonologies of natural languages, and with its adequacy for the representation of 'natural' phonological processes. In what remains of this chapter, I investigate the character of these natural phonological processes in more detail - i.e. what is it that a notational system should be able to characterise?
1.3 The requirements of a notational system

In general, there is agreement among phonologists as to what a notational system has to be able to represent. It is assumed that in phonological processes in languages, certain classes of segments tend to recur - i.e. certain classes of segments repeatedly undergo change, function in the environments of phonological rules, etc. - to a greater extent than other classes of segments. Such recurrent classes are often referred to in the literature as 'natural classes' (see, for example, Hyman 1975a:139-142), and it is the contention of most phonologists that only natural classes (as defined by the particular notational system being used) should recur in the specifications of the processes in the phonology of any language. One of the functions of a notational system, then, is to be able to distinguish the classes of segments which recur in rules from the classes of segments which do not.

I assume that, in setting up a notational system, we do not need to take account of what have been referred to as 'crazy rules' (Bach and Harms 1972), i.e. idiosyncratic rules which appear to be phonologically unmotivated, and which may be the relics of phonologically natural processes at an earlier stage of the language. In that such rules do not recur in languages, they fall outside the scope of the notational system - their idiosyncratic behaviour means that the notational system is not required to offer a 'natural' characterisation.

It is further accepted by most phonologists that the recurrence of particular classes has some kind of phonetic motivation. That is to say, associated with a natural class there is some phonetic property (or perhaps a combination of properties), which serves to distinguish the class from any other given set of segments in the language in question. On the other hand, it is not possible to associate with a set of segments which does not form a natural recurrent class any set of phonetic properties which the segments have in common. In other words, then, natural classes are not (phonetically) random sets of the possible classes of segments in languages.
For those phonologists who accept that natural classes have a phonetic basis, it seems reasonable to demand of a notational system that it should reflect this basis; i.e. that the elements of the system, whatever they may be, should correspond in some sense with the phonetic properties defining the natural classes. There are, then, two demands which our notational system must meet - firstly, to represent appropriately the recurrent nature of phonological classes, and, secondly, to represent the phonetic basis of the natural classes. The assumption that a notational system should meet these two requirements is formulated by Anderson (1980:165) as the natural recurrence assumption, given as (1.12):

(1.12) natural recurrence assumption:
(a) phonological classes are not random
(b) phonological classes and the relations between them have a phonetic basis

Although most phonologists would agree that the two parts of the natural recurrence assumption are interrelated, some, notably Foley (1977), would not, and I propose, in the first instance, to examine the issues separately.

1.4 Recurrence

In the expression of phonological 'rules' (within componential systems of notation), the class of segments affected by a rule is represented in terms of the property shared by the segments in question; the segments involved, then, are not simply listed as indivisible entities. We can illustrate this with virtually any rule affecting more than one segment from recent works on phonology.

Consider, for example, the treatment by Lass and Anderson (1975: §5.3) of the distribution of voice in Old English (OE) fricatives. They present the following data (their (5.32)):
It would be possible to write a 'non-componential' rule such as (1.14) to account for the voicing of the fricatives in (1.13):

\[
\begin{align*}
(f, s, \theta) & \rightarrow \{ v, z \} / X & Y \\
\{ v, z, \delta \} & \rightarrow \{ \text{vowel and sonorant consonants} \} / X & Y
\end{align*}
\]

(where X and Y would be lists of all the possible vowels and sonorant consonants between which fricatives can occur in OE). Such a formulation, it is argued, obscures the fact that the segments \([f, s, \theta]\) (or indeed \([v, z, \delta]\)) form a class that is recurrent, and similarly that the set of vowels and sonorant consonants in OE (i.e. X and Y) is also a recurrent class. That is, \([f, s, \theta]\) are not random, but form, rather, a systematically recurrent class, in this case the class of 'voiceless fricatives'. Recurrent classes, then, share some kind of property, and it is the job of the notational system to be able to characterise this property. Within the notational conventions of binary distinctive feature phonology, Lass and Anderson write a rule reproduced as (1.15):

\[
\begin{align*}
\text{[+obs] +cont} & \rightarrow [+\text{voice}] / [-\text{obs}] \quad [-\text{obs}]
\end{align*}
\]

(i.e. a continuant obstruent (fricative) is voiced between two non-
obstruents (sonorants)). (1.15), then, is meant to characterise uniquely (as far as the OE system is concerned) the state of affairs in (1.14). Thus, a recurrent class is characterised within such a notational system by a set of 'components' which are unique (as a set) to that class, and which enable generalisations to be made about it.

'Natural classes' may also be formed by sequences of segments. Consider, for example, the behaviour of the diminutive suffix in Modern Dutch (for a detailed discussion of this phenomenon, see chapter 11). In Dutch, the surface form of the suffix may be [je], [tje], [pjæ], [kje], or [ætje]. The choice amongst at least some of these forms is predictable from the phonological environment. In particular, the choice of, on the one hand, [tje], [pjæ], or [kje], and, on the other, [ætje], depends not only on the last segment of the word to which the diminutive suffix is to be added, but also on other information, as in (1.16):

(1.16) a. raam 'window' 
boom 'tree' 
duim 'thumb' 
\textit{diminutive in [pjæ]} 
maan 'moon' 
boon 'bean' 
\textit{tuin} 'garden' 
\textit{diminutive in [tje]} 
\begin{align*}
\text{zalm} & \rightarrow 'salmon' \\
\text{helm} & \rightarrow 'helmet' \\
\text{worm} & \rightarrow 'worm' \\
\text{diminutive in [pjæ]} & \\
\text{urn} & \rightarrow 'urn' \\
\text{tarn} & \rightarrow 'rip' \\
\text{horn} & \rightarrow 'horn' \\
\text{diminutive in [tje]} & \\
\end{align*}

b. kam 'comb' 
stem 'voice' 
gum 'eraser' 
\textit{diminutive in [ætje]} 
gang 'corridor' 
ring 'ring' 
kreng 'bitch' 
\textit{diminutive in [ætje]}
In (1.16a) and (b) we see that the choice of the suffix depends not only on the last segment - for example, both [tja] and [atja] occur immediately after /n/ - but also on the character of the segment immediately preceding the last segment. In (1.16c), however, a further complication is introduced. We find, for example, both [kja] and [atja] after the sequence <ing> (e.g. <koninkje> and <ringetje>). If we accept that the form of the suffix is, indeed, phonologically predictable (see again chapter 11), then it is clear that whole sequences of segments may be said to form a class - a class which should be represented in the notational system.

It will be one of the arguments of the following chapters that notational systems proposed to date fail to account adequately for recurrent groupings - both in terms of the segment and in terms of sequences of segments.

1.5 Natural processes

Associated with the notions of naturalness and recurrence is the notion of 'natural process'. Natural processes, as we might expect, are those in which one natural class of segments changes into another natural class of segments, generally in the environment of
other sets of segments, which themselves form natural classes. Further, natural processes are recurrent. Thus, for example, the well-known sound change of OE i-umlaut involves the fronting of back vowels, and the raising of low front vowels to mid vowels, in the environment of [i] or [j] in the following syllable. This gives the following set of alternations in OE (Lass and Anderson 1975:117):

<table>
<thead>
<tr>
<th>Alternation</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>û  y</td>
<td>cup 'known': cûpan 'make known'</td>
</tr>
<tr>
<td>u  y</td>
<td>burg 'city': byrlg 'id. dat. sing.'</td>
</tr>
<tr>
<td>ð  ð (ã)</td>
<td>dâm 'judgement': dëman 'judge'</td>
</tr>
<tr>
<td>0  ø (e)</td>
<td>ofost 'haste': efstan 'hasten'</td>
</tr>
<tr>
<td>ā  æ</td>
<td>hål 'whole': hålan 'heal'</td>
</tr>
<tr>
<td>a  æ</td>
<td>mann 'man': menn 'men'</td>
</tr>
<tr>
<td>a  æ</td>
<td>faran 'go': færst 'id. pres. 2 sing.'</td>
</tr>
</tbody>
</table>

(Lass and Anderson argue that, synchronically, [e] in <menn> is the umlaut of a derived [æ], not of [a]. I shall not pursue this matter here.) They formulate the following rule to characterise the process (for simplicity, I consider only short vowels affected by i-umlaut):

\[
\begin{align*}
\left[ \begin{array}{c}
-\text{cons} \\
[+\text{back}] \\
[-\text{back}] \\
[+\text{low}] \\
\end{array} \right] & \rightarrow \left\{ \begin{array}{c}
[-\text{back}] \\
[-\text{low}] \\
\end{array} \right\} / C_0 \left[ \begin{array}{c}
-\text{back} \\
+\text{high} \\
\end{array} \right]
\end{align*}
\]

We may assume that OE i-umlaut is a natural process, in that it appears to involve some kind of phonetic assimilation process (specifically, backness or height assimilation of a vowel to a vowel or semi-vowel in the following syllable). Further, processes similar to OE i-umlaut recur in many languages of the world; hence both parts of the natural recurrence assumption are evidenced by the process. We should, therefore, pose several questions about the rule in (1.18). First of all, are the various sets of segments involved shown by the notation to be natural classes? That is, do the input, the output, and the environment all constitute natural classes, as defined within
the particular notational system in question? Secondly, does the notational system show that a natural process is involved? In other words, does the notational system allow the expression of the relationships between the input, the output, and the environment in such a way as to bring out the naturalness of the process? Thirdly, does the notational system adequately reflect the unitary nature of the process of OE i-umlaut? If i-umlaut is a single process (as has traditionally been assumed within historical work), is it notationally appropriate to have what appear to be two sub-parts in the input and output of the rule, as in (1.18), or is there something common to the two sub-parts that is not captured by (1.18)?

It is clear that the notions of natural class and natural process are interrelated. Nevertheless, a failure to distinguish the two adequately may lead to problems for the notational system. For example, we have seen that i-umlaut is a natural process. One of the sub-parts of the rule gives [y] as the mutated form of [u] - a process which appears to be natural in phonetic terms, in that it involves assimilation of a back rounded vowel, which becomes a front rounded vowel under the influence of the front vowel or semi-vowel in the following syllable. However, although the process itself is natural, the notational system of sPE cannot show that the output of the process is also natural.

This situation arises as a result of the introduction into Chomsky and Halle's binary distinctive feature system of the notion of 'markedness'. Some sounds are more 'marked' (i.e. less natural) than others. Specifically, [y] is more marked than either [i] or [u], on the basis that front rounded vowels occur less frequently in languages than either of the other series (for exposition, see sPE: ch.9, Kean 1980; and for a fuller discussion, see chapter 2 below). Chomsky and Halle assume that changes in languages will tend to change more marked segments into less marked segments, and characterise this by means of a linking principle whereby the output segment of a process is assigned the unmarked value for any features which are not mentioned in the rule itself, and whose markedness value
depends on the values of features which are mentioned in the rule. However, the markedness metric then fails in the case of OE i-umlaut; the output, [y], is more marked than the input, [u]. The sPE notational system fails to show that the output of i-umlaut is the expected output (i.e. the process is natural), even though the output itself is apparently more complex than the input. The sPE markedness theory would, in fact, predict [i] to be the expected output, in that for front vowels the value [-round] is the unmarked value, while [+round] is marked.

The failure to distinguish naturalness of process from naturalness of class, then, leads to problems of the type just outlined. I shall return in greater detail to some of the problems associated with markedness theory in chapter 2. For a fuller discussion, see sPE: ch.9, Lass and Anderson (1975: App.IV), Kean (1980).

1.6 The phonetic basis

Generally associated with the belief that the elements of the notational system should allow the expression of recurrent classes as opposed to non-recurrent classes is the belief that these elements should have some kind of phonetic correlate, i.e. that recurrent classes are recurrent just because they can be associated with some phonetic parameter. Nearly all phonologists appear to hold this view; thus, the features of (1.15) ([obs], [cont], [voice]) are associated with various phonetic properties (although there may be disagreement as to what the appropriate phonetic correlate for a particular feature may be).

An examination of Lass and Anderson's treatment of OE Breaking illustrates a typical approach to this problem. Breaking is traditionally said to be the diphthongisation of a vowel before the consonant groups "[i]+C, [e]+C and [x](C)" (where C = 'any consonant') (Lass and Anderson 1975:74). Lass and Anderson give the following examples (their (3.1)):
The problem which arises concerns the nature and phonetic specificity of the environment for Breaking. Specifically, what is it about /l/, /r/, and /x/ that causes Breaking to take place? On the assumption that such a class should be natural, i.e. that it has phonetic properties in common which can distinguish it from other classes (natural or non-natural), the class of /l/, /r/, /x/ appears at first sight to be deviant, if /l/ is a voiced alveolar lateral, /r/ some kind of voiced alveolar trill or approximant, and /x/ a voiceless velar fricative.

The assumption that OE Breaking was, in fact, a natural process leads Lass and Anderson to interpret /r/ and /l/ in such a way that they do share unique (for OE) phonetic characteristics with /x/. Specifically, they consider OE /r/ to be a uvular continuant (fricative or trill), and /l/ to be a velarised dental lateral. The details of the arguments in support of these particular phonetic realisations need not concern us here; however, what is important is that this allows Lass and Anderson to characterise the class of segments causing Breaking as (1.20):

$$(1.20) \begin{cases} +\text{cons} \\ +\text{cont} \\ +\text{back} \end{cases}$$

i.e. as consonants without complete closure produced with raising of the back of the tongue. Thus OE Breaking can be interpreted as a natural phenomenon, at least to the extent that its environment is natural; i.e. phonetically based.

Although the details of the Lass and Anderson formulation of the rule of OE Breaking are not relevant here, what has just been discussed represents a fairly typical approach to such problems on the part of phonologists accepting the point of view that recurrent
classes are phonetically natural. Another important strand in what follows, then, will be concerned with the extent to which proposed notational systems are adequate in achieving the goal of naturalness; that is, is the correspondence between the elements of a notational system and phonetic parameters optimal? For example, is the set of elements in (1.20) the most appropriate for the characterisation of the natural class of segments /r, i, x/ (if they do, in fact, represent [u (or r), i, x] respectively)?

Before going on to discuss these matters in detail, we should notice again that the claim that notational systems should be phonetically natural is not accepted by everyone. In particular, Foley, in a series of publications, has consistently taken the view that the elements of a phonological system are merely elements of an abstract theoretical system, and as such cannot be said to have any phonetic correlates (see, for example, Foley 1970, 1973, 1977, 1979). "It should be stressed that it is...the concept of establishing phonological elements independent of phonetic definition which is important. Only when phonology frees itself from phonetic reductionism will it attain scientific status." (1977:52).

A similar view is held by Fudge (1967), who holds that the basic phonological elements must be completely abstract, and that "although there may be individual cases where a phonetically-based system handles [the systematic phonemic] level adequately, there will be others where such a system fails... The logical conclusion is that phonologists (above all, generative phonologists) ought to burn their phonetic boats and turn to a genuinely abstract framework." (1967:26).

Such views have been criticised in various places (Cohen 1971, Ohala 1974, Smith 1979; for some discussion, see Lass 1980:39ff). The criticisms centre around the fact that abstract phonological elements in the the theories of Foley and Fudge are invariably realised as phonetic events. Each abstract phonological element must be mapped onto some phonetic correlate, and a theory which refuses to admit that phonological elements have some kind of phonetic basis
only serves to obscure the way in which phonological systems operate. Rather than being a theory of language, such a theory is an abstract system, whose elements 'happen' to be manifested by phonetic elements.

1.7 Phonological complexity

A further aspect which we may expect to be reflected in our system of notation is that of 'phonological complexity'. This notion owes its origin to the work of Jakobson (1941). He establishes the existence of certain 'structural laws', which are based on evidence from various phonological areas - language acquisition, aphasia, and phonological systems. In language acquisition, phonological segments are acquired in a fixed order, such that the acquisition of a particular segment, say /X/, depends on the previous acquisition of various other sounds, say /Y/ and /Z/. In various kinds of aphasia, in which the phonological segments are progressively lost, the same pattern holds in reverse. Thus the loss of /Y/ and /Z/ in this example would presuppose the previous loss of /X/. Similarly, in the phonological systems of languages of the world, the presence (as a phonological segment) of /X/ is dependent on the presence of /Y/ and /Z/. Thus, Jakobson would argue that the same structural laws hold in all these areas - in this case, /Y/ and /Z/ are less complex sounds than /X/.

I assume that the facts outlined above have some kind of phonetic, perhaps perceptual basis (for some discussion see, for example, Stevens 1972, Lieberman 1976), and that as such, the proposition that some sounds are phonologically simpler than others should be reflected in the notational system. I am not at this stage concerned with the details of relative complexity - i.e. just which segments are simple and which complex - but the degree to which a particular notational system reflects such relative complexity will be a factor which will be used throughout the following chapters in assessing its suitability.
1.8 Non-componential systems

It seems that theories which are non-componential, i.e. those in which the segment is treated as an indivisible entity lacking any internal structure, can meet none of the criteria discussed above. They cannot show classes to be recurrent, and therefore cannot show what they have in common phonetically, and as all segments are represented by a single symbol or label, no degrees of complexity can be distinguished.

In fact, however, few proposals for non-componential systems have been made, although Bloomfield (1926), and other workers in the tradition of American phonemics, do treat the phoneme as a minimal unit. Later treatments, such as those of Hockett (1947, 1950) also characterise the segment as being phonologically atomic, although at the phonetic level some degree of internal structure is invoked.

In the following chapters, then, I shall be concerned only with componential systems, and will assume that non-componential systems are in principle unable to meet the criteria which we must demand of a notational system. In other words, I take it that the componentiality assumption (Anderson 1980:166) is valid for any adequate system of representation:

\[(1.21) \text{componentiality assumption}\]

the representation of the internal structure of segments is such as to optimise the expression of phonological relationships that are (a) recurrent and (b) natural

In chapter 2, I shall discuss what can be looked upon as the standard componential systems in use today, systems based on the distinctive feature, whether binary or not.
Chapter 2

Notational Systems 2: Distinctive Features

As was noted in chapter 1, the most widely used componential system of phonological notation is based on the concept of the distinctive feature, and in (1.1) the feature specification of a particular segment was given. A 'specified feature' such as [+cons], then, "is an ordered pair consisting of a symbol representing a position on an axis followed by the name of the axis" (Sommerstein 1977:94). In this case, '+' is the position on the axis (on which there are only two possible values, '+' and '-'; but see below), and the axis is [cons]. The position on the axis is generally referred to as the value of the particular feature. It is generally accepted by distinctive feature phonologists that the axis corresponds to some phonetic parameter. For the feature [consonantal], for example, Chomsky and Halle provide the following definition (spe:302):

Consonantal sounds are produced with a radical obstruction in the midsaggital region of the vocal tract; non-consonantal sounds... without such an obstruction.

A segment is defined by an unordered set of these ordered pairs, and segments can be shown to be more or less similar according to the number of feature-values which they have in common. Further, natural classes of segments can be specified on the basis of shared feature-values or sets of feature-values (see §1.4). Thus, most distinctive feature phonologists accept the notion that the phonological primitives - the features - should conform to the conditions of recurrence and naturalness discussed in §§1.4-1.6; i.e. they accept the natural recurrence assumption in its entirety.

However, although there is this measure of agreement as to what a distinctive feature notational system should achieve, there have
nevertheless been various proposals as to how this should be done, and we can distinguish various different schools of thought amongst distinctive feature phonologists. Perhaps the most important distinction is between 'binary' and 'non-binary' theories: in the former, each feature has only two values phonologically - generally '+' and '-' - while in the latter, features may have more than two values. In §§2.1-2.3 I consider some of the binary and non-binary feature systems which have been proposed, while in §2.4 I look at a particular 'problem area' associated with distinctive feature theory, and at some of the attempts that have been made to resolve these problems.

2.1 Binary distinctive feature theories

The notion that segments should be characterised in terms of a set of binary oppositions owes its origin to Jakobson, and the first fully worked out theory is to be found in Jakobson et al (1952) and Jakobson and Halle (1956). Jakobson et al (1952:3), for example, state:

The listener is obliged to choose either between two polar qualities of the same category, such as grave vs. acute, compact vs. diffuse, or between the presence and absence of a certain quality, such as voiced vs. unvoiced, nasalized vs. non-nasalized, sharpened vs. non-sharpened (plain). The choice between the two oppositions may be termed distinctive feature.

Thus, although there is phonetically "a continuous variation in the shape of the lips from a close rounding to spreading", Jakobson et al (1952:9) claim that "no language possesses more than one minimal distinction based on the size of the lip orifice", and state that "the dichotomous scale is the pivotal principle of the linguistic structure".

The notion of binary opposition is carried over into the system to be found in SPE. Indeed, Chomsky and Halle claim, without attempting to justify their position, that "the natural way of indicating whether or not an item belongs to a particular category is by means of binary features" (SPE:297). I shall consider some evidence below which appears to throw doubt on this claim. In the meantime, however,
I shall examine some of the more important aspects of the Jakobsonian and SPE feature systems.

2.1.1 The Jakobsonian feature system

The feature system of Jakobson et al (1952) represents a development from the concept of 'phonological properties' associated with the Prague School. Thus, for Jakobson, a feature such as [+consonantal] is a phonological property which serves to distinguish those phonemes which are characterised as [+consonantal] from those which are not. The features, however, are not themselves meant to provide a detailed phonetic specification of segments. This interpretation of the role of the notational system allows Jakobson to propose that a small number (around 12-15) of features is adequate to characterise the phonological oppositions of all the languages of the world. Because he is not concerned with specifying precise phonetic differences between sounds, such differences can be subsumed under a single phonological opposition, where appropriate. Thus Jakobson et al (1952: 6) consider the difference in place of articulation between the velar stop /k/, the palatal nasal /n/, and the prepalatal constrictive /ʃ/ in French "to be entirely redundant, for this difference is supplementary to other, autonomous distinctions. All of these consonants are opposed to those produced in the front part of the mouth as compact vs. diffuse." Thus, French /p b/ and /t d/ bear the same relationship to /k g/ as /f v/ and /s z/ do to /ʃ ʒ/, and /m/ and /n/ to /n/. /k ʃ/ are simply (in traditional terms) back consonants, as opposed to the other, front, consonants. The difference in place of articulation amongst the three back consonants is not a phonological matter in French, and therefore need not be represented by the feature system, in which they will all be characterised as compact.

Similarly, a feature such as tense vs. lax (Jakobson et al 1952: 36) has various articulatory correlates: tense vowels are longer than corresponding lax vowels (e.g. Fr. /sqt/ <saute> vs. /sot/ <sotte>), while the tense vs. lax distinction for English consonants corresponds to traditional fortis vs. lenis (e.g. /pI/ <pill> vs. /BI/ <bill>).
Phonologically, the difference between Fr. /œ/ (=[o]) and /o/ (=[ɔ]) is the same as that between Eng. /p/ and /b/, although phonetically this does not seem to be the case.

Such an interpretation of the role of the notational system, however, makes it difficult for some spurious generalisations to be avoided. For example, in the Jakobsonian feature system open vowels are [compact], as are velar and palatal consonants, while close vowels and consonants articulated in the front part of the mouth are opposed to them as [diffuse]. However, there is no obvious phonological reason to assume that, for example, open vowels and body of the tongue consonants should be specifiable as a class; i.e. this class of segments does not typically recur in phonological processes.

The Jakobsonian system, then, in that it reduces what are apparently different types of phonetic distinctions to single phonological oppositions, offers, in a number of cases, a characterisation in which certain apparently non-natural classes may be represented as having the same feature-values. For example, the set of grave compact sounds would include /œ o/ and /x k/, a set of sounds which does not appear to be a likely candidate for a recurrent class.

To some extent, this situation results from Jakobson's decision to create the smallest possible set of features adequate for the description of all phonological oppositions in all languages. Partly, too, it arises from the way in which the features are defined. The definitions are based on acoustic properties (although articulatory prerequisites for the acoustic stimuli are also given), and while /œ o/, on the one hand, and /x k/, on the other, may display the same kind of acoustic properties - i.e. in showing a spectrum in which "the lower side predominates" (i.e. [grave]), and in which the first formant is close to the other formants (i.e. [compact]) - the articulatory correlates are quite different. In fact, it only makes sense to say that segments have certain properties to the extent that a comparison is being made with other segments which are otherwise similar, so that /œ o/ are grave compared with front vowels and compact compared with close vowels, and /x k/ are grave compared with palatal
consonants and compact compared with non-tongue body consonants. That is, 'gravity' and 'compactness' are not absolute properties, but are relative to segments otherwise similarly specified - an important aspect of the Jakobsonian system.

It is this aspect of the notational system of Jakobson et al which leads to the possibility of representing these non-natural classes. The desire to have as few features as possible creates an insufficiently constrained notational system in this respect. On the other hand, the theory is inadequate as a notational system in that it is just so limited. As it is only designed to characterise phonological oppositions, many 'sub-phonemic' phenomena cannot be characterised, such as the different allophonic realisations of phonemes, or historical changes in which the phonemic status of a segment and its relationship to other phonemes remains unaffected. If we accept the notion that a notational system should be concerned with phonetic specifiability - i.e. that the system should not only characterise phonological oppositions as Jakobson supposed, but should be able to characterise sub-phonemic detail as well, as Chomsky and Halle (SPE), Ladefoged (1971), and Schane (1973a) all assume - then a system such as Jakobson's must necessarily be inadequate.

There have been proposals which have aimed to retain the universality of the Jakobsonian system while at the same time incorporating the notion of phonetic specifiability. Wilson (1966), for example, suggests that the Jakobsonian phonological feature [flat] should be retained on one dimension, while, in the case that the value for this feature is '+', it should be rewritten onto another dimension as whichever of its articulatory correlates (e.g. labialisation, velarisation, pharyngealisation) is appropriate. Thus the relational aspect of the Jakobsonian features is retained, and the phonological claim that no two articulatory phenomena corresponding to the acoustic feature of flattening (lowering of one or more formants) can be in contrast in any language is preserved, while the particular articulatory realisation can also be specified. In effect, what we have here is a mapping between the phonological and phonetic levels, without a necessary one-to-one correspondence between the features involved.
2.1.2 The SPE system

The feature system proposed by Chomsky and Halle, although derived from that of Jakobson, differs in some important respects. Firstly, as noted above, the function of the notational system of SPE is extended so that it should be able to account not only for phonological oppositions, but also, at least in principle, for the phonetic specification of segments. Thus, Chomsky and Halle (SPE:299) note that "the individual features ... together represent the phonetic capabilities of man". This means that many more features are required, as, in the definition of his acoustic features, Jakobson had subsumed distinct articulatory phenomena, on the grounds that these were never to be found in phonological opposition in any one language. As an example, we may cite again the much discussed case of the Jakobsonian feature flat vs. plain (Jakobson et al 1952:31). The (acoustically defined) feature of flattening "manifests itself by a downward shift of a set of formants ... in the spectrum". However, this feature may be realised by different articulatory means - by labialisation, velarisation, or pharyngealisation. As it is claimed that these different articulatory phenomena are never in phonological opposition (although this has been disputed since), there is no need to establish features to characterise each separately; rather, the single acoustic feature flat vs. plain is adequate to characterise phonologically "the two phonetic signs [t^] and [±] used for rounded and pharyngealized consonants" as opposed to consonants without such secondary articulations (Jakobson et al 1952:31). In the SPE model, however, these three different articulatory phenomena must be given different feature characterisations, partly because Chomsky and Halle accept that the phenomena can in fact function to distinguish items phonologically, but more importantly, because phonetic specificiability is in any case required.

This fundamental theoretical difference between the two notational models leads to certain other differences. A consequence of the need to give the features a phonetic as well as a phonological function is that they may, at the phonetic level, no longer be binary. Thus, a feature may have any number of values at the phonetic level,
depending on the degree to which the phonetic property characterised by that feature is present. Chomsky and Halle do not, in fact, discuss precisely how this is to be done, i.e. the phonological representations are to be mapped onto the phonetic representations, but we may assume that, phonetically, the feature [nasal] might have \( n \) values as in (2.1):

\[
(2.1) \quad [0 \text{ nasal}] \\
[1 \text{ nasal}] \\
[2 \text{ nasal}] \\
[3 \text{ nasal}] \\
\vdots \\
[n \text{ nasal}]
\]

where [0 nasal] would mean that the nasal mechanism (i.e. lowering of the velum) is not used, while any other value implies that the velum is lowered, thus allowing air to escape through the nose; as the value increases, so the degree of lowering of the velum becomes greater, and the amount of air escaping through the nose increases.

At the phonological level, however, as noted above, Chomsky and Halle maintain the Jakobsonian binary hypothesis. Thus all features have either '+' or '-' as phonological values, and no other values are possible.

A further way in which the \( SPE \) features differ from those of Jakobson is in the basis of the definitions. While Jakobson's features are defined in terms of acoustic parameters, the \( SPE \) features have an articulatory basis. Thus features with the same name may be defined quite differently in the two frameworks. For example, Jakobson et al (1952:36) define the feature tense vs. lax as follows:

In contradistinction to the lax phonemes the corresponding tense phonemes display a longer sound interval and a larger energy.

In Chomsky and Halle's definition (\( SPE:324 \)), however:

Tense sounds are produced with a deliberate, accurate, maximally distinct gesture; nontense sounds are produced rapidly and somewhat indistinguishably.

All the \( SPE \) features, then, are defined articulatorily, even features such as [sonorant], whose acoustic properties - greater energy (see
Sonorants are sounds produced with a vocal tract cavity, configuration in which spontaneous voicing is possible; obstruents are produced with a cavity configuration that makes spontaneous voicing impossible.

This definition, indeed, contains a notion which has been attacked as having no experimental phonetic justification - the notion of different cavity configurations determining whether spontaneous voicing is possible (see Ladefoged 1971:109-110 for discussion).

However, for many features, it seems reasonable to say that the SPE system is merely a reworking in articulatory terms of Jakobson's features. That is, although a particular feature in SPE may have a different name and definition as compared with the corresponding feature in the Jakobsonian framework, it is nevertheless the case that the sets of segments defined by equivalent feature-values in the two systems are the same. The two systems in such cases make the same claims about natural class membership - i.e. they agree that a particular set of segments is recurrent and natural - but the phonetic correlates associated with this natural recurrent class are different in the two models. Consider, for example, the case of labial and velar consonants. In both models, the set of labials and velars is characterised as forming a natural recurrent class. Jakobson uses the feature grave vs. non-grave to define the class of labials and velars as opposed to alveolars, while Chomsky and Halle introduce the feature [coronal] (SPE:304):

Coronal sounds are produced with the blade of the tongue raised from its neutral position; noncoronal sounds are produced with the blade of the tongue in the neutral position.

Thus labials and velars, which do not involve raising of the tongue, are characterised as a natural class as opposed to alveolars, for example, which do. (Notice that in the SPE model palatals, too, are non-coronal, and hence can form a class with the labials and velars, while they are non-grave in the Jakobsonian treatment, and thus have the same value for this feature as the alveolars.) Using the SPE system, Lass (1971:22) gives the following rule for the lenition of
labials and velars in OE:

(2.2) \[
\begin{bmatrix}
+\text{obs} \\
-\text{cor} \\
\text{voice}
\end{bmatrix}
\rightarrow \text{[acont]} / V \quad V
\]

The effect of the different features in the two frameworks is the same (as far as the treatment of labials and velars is concerned), although in one case the class is characterised by the positive value for the feature [grave], and in the other by the negative value for the feature [coronal].

In what immediately follows, I shall be concerned with what the Jakobsonian and SPE features have in common, rather than with the ways in which they differ; i.e. with the notion that all features should be phonologically binary, and with the way in which such binary features serve to define natural classes as opposed to non-natural classes of segments.

2.2 The binary hypothesis

Although the idea that all features are binary, at least at the phonological level, is central to both the Jakobsonian and Chomskian feature systems, it has nevertheless come under attack from many quarters. The motivation for adopting the binary hypothesis is summarised by Halle (1954:339):

Reduced to its simplest terms, Jakobson's fundamental argument was that the most satisfactory description of a language would be obtained by using as many dimensions (features) as necessary, but decreasing the accuracy of measurement, i.e., the number of significant decisions which would have to be made with regard to each dimension. The dichotomous scale, which underlies the distinctive features, has minimal accuracy of measurement: it is in this sense that it is the simplest possible.

The arguments of the Jakobsonian school, then, involve crucially the notion of simplicity, and this in turn appears to correspond to the most efficient "auditory transmission of information among human beings" (Halle 1954:340).
However, such an approach begs the question of whether each dimension or feature should on phonological grounds, rather than on grounds of 'efficiency of transmission', only have two values. In other words, is the dichotomous scale phonologically appropriate in all cases, as well as being appropriate on the grounds outlined above, as Jakobson would claim it is? Fant (1967:361), indeed, appears to concede that the binary hypothesis is a concept whose justification is non-phonological:

If properly applied, categorization according to binary principles need not come in conflict with the physical reality. It is a matter of coding convenience only.

If, then, the binary hypothesis is merely a matter of coding convenience, it can be attacked if there exist scales which are not dichotomous, i.e. those on which there are more than two phonological values. If the binary formalism obscures the phonological status of such a scale, it must be seen as unsatisfactory as a model for its description.

One area in particular has traditionally been used to illustrate this point, i.e. to argue against the belief that all features should be binary at the phonological level - the area of vowel height in languages. It has been claimed that the relationship between, say, each of the front vowels in a phonological system such as (2.3) is scalar:

(2.3) 1 u
    e o
    a o

For the proponents of such a theory, there is a single scalar dimension of vowel height, which in the case of (2.3) would have three values.

Before going on to discuss the advantages and disadvantages of binary and scalar features for the characterisation of the dimension of vowel height, we should notice that the concept of phonological oppositions other than the simple binary was familiar before the de-
velopment of the Jakobsonian features. Trubetzkoy (1939:74ff) had distinguished three different kinds of phonological opposition - privative, equipollent, and gradual. The first two are both varieties of binary oppositions - privative oppositions being those in which one member of the opposition carries a phonological mark which the other lacks, and equipollent oppositions being those in which both members of the opposition have a property which the other lacks, i.e. "both members are logically equivalent" (1939:75). Gradual oppositions are those in which the terms of the opposition have various degrees of the same property.

It has been argued by many phonologists that vowel height is, in fact, a single dimension forming a gradual opposition of the type described by Trubetzkoy (see, for example, Ladefoged 1971, 1975, Contreras 1969, McCawley 1973, Lass 1976, Sommerstein 1977, Lindau 1975, 1978). Phonologists holding this view believe that the relationship between /i/ and /e/ in (2.3) is of the same type as the relationship between /e/ and /a/ - in other words, that each vowel represents a point on a single dimension. They notice that a change such as the English Great Vowel Shift (GVS) involves the raising both of /æ:/ to /e:/ and of /e:/ to /i:/, and that these appear to be manifestations of the same kind of change, while in binary distinctive feature notation they cannot be shown to involve the same change, as can be seen from the Chomsky and Halle treatment of the (synchronic) vowel shift process in English.

As we saw in §1.2, Chomsky and Halle use two binary features [high] and [low] to characterise the dimension of vowel height. [+high] vowels are produced "by raising the body of the tongue above the level that it occupies in the neutral position", and [+low] vowels "by lowering the body of the tongue below the level that it occupies in the neutral position" (SPE:304-305). This feature assignment gives the following values for the system in (2.3):

(2.4) \begin{align*}
 [+\text{high}, -\text{low}] & : i, u \\
 [-\text{high}, -\text{low}] & : e, o \\
 [-\text{high}, +\text{low}] & : æ, ø
\end{align*}
(while the conjunction [+high, +low] is excluded, as no segment can involve simultaneous raising and lowering of the body of the tongue; for further discussion see §2.4). Thus the changes /æː/ → /eː/ and /eː/ → /iː/ in the vowel shift (cf. (1.10)) must be characterised as two separate changes, as in (2.5):

\[
\begin{align*}
(2.5) \text{a. } /æː/ & \rightarrow /eː/ \\
& \quad [\text{[+high]}] \rightarrow [\text{[-low]}]. \\
\text{b. } /eː/ & \rightarrow /iː/ \\
& \quad [\text{[+high]}] \rightarrow [\text{[-low]}].
\end{align*}
\]

in which the first change involves a shift in the value for [low] from '+' to '-', and the second a shift in the value for [high] from '-' to '+'. The two changes are not in any way shown to be formally related, as a result of the characterisation of a single phonetic dimension by two different binary features.

In the original Jakobsonian system the treatment of this area deviated somewhat from the strict binary principle to which Jakobson et al. (1952) adhered elsewhere. We find the following definition of the feature compact vs. diffuse (1952:27-28):

```
Compact phonemes are characterised by the relative predominance of one centrally located formant region... [while in] diffuse phonemes... one or more non-central formants or formant regions predominate.
```

Open vowels, such as /æ/, are compact, while close vowels, such as /i/, are diffuse. Jakobson et al. notice that mid vowels are intermediate between the two values for the 'single' feature compact diffuse, and suggest that the appropriate characterisation for these vowels is [-compact, -diffuse], i.e. a value which is intermediate between the two 'normal' values for this feature, giving the system in (2.6):

\[
\begin{align*}
(2.6) \text{[diffuse]} & \quad [\text{[-]}] \quad \text{I} \quad \text{u} \\
\text{[-compact, -diffuse]} & \quad [\text{[±]}] \quad \text{e} \quad \text{o} \\
\text{[compact]} & \quad [\text{[+]}] \quad \text{æ} \quad \text{a}
\end{align*}
\]

(2.6), although apparently similar to (2.4), differs in that only a single feature is involved, which has, in addition to the usual
two values for the features in the Jakobsonian system, an intermediate value for the mid vowels. "The opposition compact vs. diffuse in the vowel pattern is the sole feature capable of presenting a middle term in addition to the two polar terms." (1952:28). Jakobson et al suggest that the use of the symbol [±] is appropriate to show the status of this middle term, and notice further that it would be possible to resolve "this opposition of two contraries" into "two binary oppositions of contradictories: compact vs. non-compact and diffuse vs. non-diffuse". Such a solution, however, seems to be merely an instance of what Fant calls a matter of coding convenience - it is difficult to see that there is any genuine phonological evidence to support the setting up of two distinct binary features.

The arguments against the use of binary features in this area becomes even more compelling when we consider vowel systems with four, rather than three, systematic heights. As we have seen, both the Jakobsonian and Chomskian feature systems only allow for the expression of three heights, as it was maintained that this is the maximum number of phonological oppositions which are made in this area in any one language. However, it has been claimed by many linguists that there are languages in which four systematic heights are found (see, for example, Kiparsky 1968 on Swiss German, Ladefoged 1971 on Danish, Ewen 1977 on Scots).

Within systems with four vowel heights, we find processes similar to the Eng. GVS. Lindau (1978:545) cites the following diphthongisation process in Scanian, a Swedish dialect spoken in Malmö, in which the epenthesised element is one degree lower than the original vowel:

\[(2.7) /ɛ/: \rightarrow [æɛ], /e/: \rightarrow [æe], /o/: \rightarrow [æo], /a/: \rightarrow [æa]\]

As (2.7) involves a four height system ([i], [e], [ɛ], [æ]), the SPE system is unable to account for it.
Wang (1968) has proposed a rather different binary feature system, by means of which it is possible to characterise four vowel heights, as in (2.8):

\[(2.8) \begin{array}{ll}
[+\text{high}, -\text{mid}] & i \\ [+\text{high}, +\text{mid}] & e \\ [-\text{high}, +\text{mid}] & \varepsilon \\ [-\text{high}, -\text{mid}] & \omega
\end{array} \]

Lindau observes that this feature system allows the characterisation of (2.7) as (2.9):

\[(2.9) \ v \rightarrow \begin{bmatrix} V \\ \text{ahigh} \end{bmatrix} / \begin{bmatrix} \text{ahigh} \\ \text{amid} \end{bmatrix}\]

but goes on to say:
The rule predicts the correct inserted vowel, but... wrongly implies that two separate phonetic mechanisms are involved. The rule must be fully deciphered before one can determine that a vowel-lowering process is described.

It seems, then, that strict binary distinctive feature theory is inadequate for the characterisation of phonological scales such as vowel height. It is unable to handle the notion of dimensions having more than two values.

2.3 Non-binary distinctive feature theories

The inability of binary feature theory to characterise adequately processes such as raising and lowering of vowels of various heights led Ladefoged (1971) to propose that some features are not binary, but multivalued; that is, that a particular feature might have more than two values phonologically. This point of view has been developed in various other works - see, for example, Contreras (1969), Saltarelli (1973), Ladefoged (1975), Lindau (1975, 1978), Williamson (1977). Proponents of such theories believe that "there is no justification for regarding any single phonetic parameter as a composite of binary
features" (Lindau 1978:545), and suggest instead that the dimension of vowel height, which, they claim, is just such a single phonetic parameter, should be characterised by a single multivalued feature.

We can distinguish two types of non-binary features. The first are scalar features such as Ladefoged proposes for the characterisation of vowel height, as in (2.10):

(2.10) [1 height]
     [2 height]
     [3 height]
     ...
     [n height]

where n is the number of systematic vowel heights in a particular language, and each feature-value represents a point on a continuous scale, as in (2.11):

(2.11) 1 2 3 4

height

The second type are what Ladefoged (1971:43) refers to as multi-valued independent features. Ladefoged proposes a non-binary feature for the characterisation of articulatory place, which may have up to ten values (although he suggests that no more than six would occur contrastively in any one language), as in (2.12):

(2.12) [articulatory place] - bilabial
      labio-dental
dental
alveolar
post-alveolar
palatal
velar
uvular
pharyngeal
glottal
labial-velar
labial-alveolar

Ladefoged suggests (although he does not commit himself to the view) that it is possible to view [articulatory place] as a multi-
valued independent feature, i.e. that "the places of articulation form an unordered set" (1971:44), in which the values do not, as in the case of a scalar feature, occur as points on a continuum.

The adoption of a scalar feature to characterise vowel height allows a unitary formulation of processes such as (2.5), in which low vowels are raised to mid, and mid vowels to high. The feature-values in (2.13) allow a rule such as (2.14):

(2.13) \[ \begin{align*}
[3 \text{ height}] & : \imath \quad \text{u} \\
[2 \text{ height}] & : \epsilon \quad \text{ø} \\
[1 \text{ height}] & : \text{æ} \quad \text{a}
\end{align*} \]

(2.14) \[ [n \text{ height}] \rightarrow [n+1 \text{ height}], \text{ where } n = 1, 2, 3 \]

I ignore here, as in (2.5), the diphthongisation of the high vowels in the vowel shift process - an aspect of the vowel shift which raises problems rather different from those at present under discussion.

The Swedish diphthongisation process cited by Lindau and reproduced as (2.7) is also given a more satisfactory account within the multivalued feature system. Lindau uses the following feature-values to characterise the four height vowel system:

(2.15) \[ \begin{align*}
[1 \text{ high}] & : \imath \quad \text{y} \quad \text{u} \\
[2 \text{ high}] & : \epsilon \quad \emptyset \quad \text{ø} \\
[3 \text{ high}] & : \epsilon \quad \text{æ} \quad \text{a} \\
[4 \text{ high}] & : \text{æ}
\end{align*} \]

(Notice that Lindau considers high vowels to have the lowest value for the feature, and low vowels to have the highest.) Using these feature-values, she gives the following rule for the diphthongisation process:

(2.16) \[ \emptyset \rightarrow [n+1 \text{ high}] / [n \text{ high}] \]
Lindau claims that (2.16), as opposed to (2.9), immediately captures the generalisation that the new vowel is one step lower than the original one.

The problems raised by the binary notation, then, appear at first sight to be resolved by the adoption of a scalar feature framework. However, there are other problems inherent in this framework which are not apparent in the binary notation. In particular, how can we write non-binary rules which refer to particular subsets of the full set of values of a multivalued feature such as [height]?

This does not create difficulties if only one value needs to be referred to. For example, in Dutch diminutive formation, the only circumstances under which either [atjə] or [tjə] may be chosen as the diminutive suffix after a word ending in a vowel followed by a sonorant consonant is if the vowel in question is high (/i/, /y/, /u/). Within the binary notation we can characterise these vowels as [+high], and within the scalar notation as [1 high]. However, if the subset contains more than a single value, the scalar notation does not characterise the class involved in a way which can be considered satisfactory. We may illustrate this by considering one aspect of the process known as Open Syllable Lengthening in Middle English (MEOSL). Lass (1976:69) cites the following two rules, which may be taken to be appropriate for the lowering stage of the MEOSL process:

\[(2.17)\]

\[a. \{e, o\} \rightarrow \{ε, o\} \]

\[b. \{i, u\} \rightarrow \{ε, o\} \]

A process such as this, then, involves the lowering of all non-low vowels. Unlike the high vowels in the vowel shift process discussed earlier, to which (2.17) appears similar, the low vowels are not affected in any way by this process - that is /a/ remains /a/ and fails to undergo diphthongisation or raising.

In the binary notation, the class of non-low vowels undergoing this change can be characterised simply as [-low] (or in Wang's system
as [+high]) - although notice that the formulation of the rule itself presents great problems (see for discussion Pelt 1979). In the scalar notation, however, the only possibility appears to be a rule such as (2.18):

\[(2.18) \quad V_{\text{n height}} \rightarrow [\text{n-1 height}], \text{where } n \geq 2 \text{ (or where } n \geq 3, \text{ in a four height system)}\]

It is difficult to imagine what concept of naturalness could be appealed to if a rule such as (2.18) is to be considered natural. While a representation such as [-low] seems to characterise a well-defined class of segments, there do not seem to be any grounds for deciding whether '[$\text{n height}$], where $n \geq 2'$ is any more or less natural than any of the representations in (2.19):

\[(2.19) \quad [\text{n height}], \text{ where } n \geq 3\]
\[\quad [\text{n height}], \text{ where } n \geq 1\]
\[\quad [\text{n height}], \text{ where } n \leq 2\]
\[\quad [\text{n height}], \text{ where } n \leq 3\]

Thus, 'n $\geq 1$' characterises the whole dimension of vowel height, but is formally no simpler than 'n $\geq 3$', characterising only high and high-mid vowels. There appears, then, to be no evaluation metric available which would enable any sort of hierarchy of naturalness to be established with respect to representations like those in (2.18) and (2.19). Scalar features seem to be inappropriate for the characterisation of classes of segments which represent subsets of the values of a particular feature.

We can conclude from the preceding that neither binary nor scalar features are wholly adequate for the characterisation of the full range of natural classes and processes. In later chapters, various other kinds of evidence will be considered which will support this view. In the meantime, I want now to look at some proposals which have been made for the modification of distinctive feature theory in the light of its shortcomings in the expression of the problems of naturalness and recurrence.
2.4 Naturalness and recurrence in distinctive feature systems

I shall be concerned in the remainder of this chapter not only with naturalness and recurrence of class, but also of process, and with the problems these areas present to feature theory. In §§1.4 and 1.5 it was claimed that our system of phonological notation should be able to distinguish between, on the one hand, natural and recurrent classes and processes, and, on the other, non-natural, and hence non-recurrent, classes and processes. In the earlier parts of this chapter it has become apparent that non-binary varieties of distinctive feature theory fail this test with respect to the characterisation of vowel height. In what follows, we shall see that feature systems are in principle unable to distinguish adequately the two categories of phonological phenomena, without the aid of extensions to the theory, which, I shall argue, have no independent motivation.

We can illustrate this problem with some examples involving changes of one vowel to another. Any of the following might appear to be candidates for phonological processes in languages:

(2.20) a. i → u  b. i → w
c. i → y  d. u → i
e. u → w  f. u → y

In the SPE notation, the following characterisations might be appropriate:

(2.21) a. \[
\begin{array}{c}
V \\
+\text{high} \\
-\text{back} \\
-\text{round}
\end{array}
\] → \[
\begin{array}{c}
+\text{back} \\
+\text{round}
\end{array}
\]

b. \[
\begin{array}{c}
V \\
+\text{high} \\
-\text{back} \\
-\text{round}
\end{array}
\] → \[
\begin{array}{c}
+\text{back}
\end{array}
\]

c. \[
\begin{array}{c}
V \\
+\text{high} \\
-\text{back} \\
-\text{round}
\end{array}
\] → \[
\begin{array}{c}
+\text{round}
\end{array}
\]

d. \[
\begin{array}{c}
V \\
+\text{high} \\
+\text{back} \\
+\text{round}
\end{array}
\] → \[
\begin{array}{c}
-\text{round}
\end{array}
\]

e. \[
\begin{array}{c}
V \\
+\text{high} \\
+\text{back} \\
+\text{round}
\end{array}
\] → \[
\begin{array}{c}
-\text{round}
\end{array}
\]

f. \[
\begin{array}{c}
V \\
+\text{high} \\
+\text{back} \\
+\text{round}
\end{array}
\] → \[
\begin{array}{c}
-\text{back}
\end{array}
\]
(a) and (d) require the specification of two features on the right hand side of the rule (i.e. two features change value), while (b), (c), (e), (f) require the specification of only one. Thus (b), (c), (e), (f) appear notationally simpler than (a) and (d), and in any evaluation metric would, presumably, be rated as more natural. Yet, as Chomsky and Halle themselves point out (SPE:401), (a) is more to be expected in a grammar than (b), even though (b) involves fewer feature changes. Thus the distinctive feature notation fails to reflect correctly the relative naturalness of the processes involved.

More generally, distinctive feature notation allows the virtually unlimited creation of sets of apparently similar rules, which, however, differ wildly in degrees of naturalness. As was seen in (2.9), distinctive feature theory makes use of the 'paired variable convention', in which Greek letters are used to express agreement or disagreement between two values in a rule. This convention is used, for example, in the expression of various Morpheme Structure constraints in languages:

\[(2.22) \begin{array}{c}
\text{C} \\
\text{atense}
\end{array} \rightarrow [-\text{voice}] \]

\[(2.23) \begin{array}{c}
\text{V} \\
\text{low}
\end{array} \rightarrow [\text{round}] \]

(2.22) expresses the constraint that consonants in a language have opposite values for the features [tense] and [voice] - thus /p/ in English is [+tense, -voice], while /b/ is [-tense, +voice] - and (2.23) indicates that the roundness value for non-low vowels agrees with the backness value - i.e. all front non-low vowels are unround, and all back non-low vowels are rounded, as in RP. (2.22) and (2.23) represent recurrent phenomena in languages. However, (2.24) - (2.27), although apparently similar to (2.22) and (2.23), represent non-recurrent processes:

\[(2.24) \begin{array}{c}
\text{C} \\
\text{atense}
\end{array} \rightarrow [-\text{high}] \]
(2.24) - (2.27) do not represent processes which recur in languages, yet they are formally identical to (2.22) and (2.23), which do. Distinctive feature notation, then, fails to distinguish the recurrent from the non-recurrent.

Notice that these observations apply equally within non-binary feature systems. For example, in a language which contrasted four vowel heights and three degrees of backness, the feature-values [4 height], [3 height], [2 height], [1 height] and [3 back], [2 back], [1 back] would be required in a scalar feature system. Formally, such a system would allow us to write a number of spurious Morpheme Structure constraints, which would have no basis in reality, in much the same way as (2.26) and (2.27) operate within a binary framework. Consider, for example, (2.28):

(2.28) \[ V \begin{array}{c}
\phi \text{back} \\
\phi \text{round}
\end{array} \rightarrow [\geq \alpha \text{height}] \]

(where \( \alpha \) would, in this case, be a variable over the values 1, 2, 3).

The failure of distinctive feature theory in its original form to distinguish the recurrent from the non-recurrent led to various proposals which were designed to extend the system by a set of conventions whose function was to do just this. Of these, the most important was Chomsky and Halle's own theory of 'markedness'.
2.4.1 Markedness theory

Chomsky and Halle (SPE:ch.9) notice that "the entire discussion of phonology in this book suffers from a fundamental theoretical inadequacy". This inadequacy consists in the failure of their feature system to handle the problems just discussed, and they suggest that this failure is due to the fact that no account was taken of the "intrinsic content" of features. By this they mean that certain classes are "intuitively" more natural than others, but that this may not be reflected in the representations associated with the classes. They cite the example of the relative naturalness of the class of vowels which agree in backness and roundness, i.e. the class [aback, around], and the class of vowels which agree in lowness and roundness, i.e. the class [alow, around], which are shown in (2.29) and (2.30) respectively:

(2.29) [i e æ ə u]
(2.30) [i e ɪ æ ə]

While (2.29) represents a much more natural class than (2.30), exactly the same type of formal specification is required.

These observations lead Chomsky and Halle to propose that the notational system should be extended to incorporate relative naturalness, 'expectedness', or 'markedness' into the representations of segments or sets of segments. They extend their original feature specifications to include m ('marked') and u ('unmarked'), as well as '+' and '-'. m and u are replaced during the derivation of morphemes by '+' and '-' according to "universal rules of interpretation" (SPE: 403), which, "being universal, ... do not affect the complexity of the grammar". Thus, to capture the relative markedness of front unround and back round non-low vowels as opposed to front round and back unround non-low vowels, and of low unround vowels as opposed to low round vowels, they create the following 'marking convention' (their XI):
The convention (2.31) shows the vowel system (2.29) to be more natural than the vowel system (2.30).

Such a system might or might not prove adequate to predict correctly the relative markedness of classes and systems (provided that we have some independently motivated notion of what naturalness and markedness are in the first place), but it seems at best to be tacked on to rescue the inadequacies of the notational system. The introduction of the specifications u and m cannot be said to meet Chomsky and Halle's claim to be accounting for the 'intrinsic content' of their features; rather, what they seem to be doing is creating conventions to account for relative naturalness according to an externally imposed set of criteria. That is, even if their new representations reflect (supposed) relative markedness perfectly, this is only because they are designed to do just that - the circularity of the theory cannot be avoided. (For fuller discussion of this circularity, see, for example, Botha 1971, Lass 1972, Lass and Anderson 1975:App.IV.)

Furthermore, markedness theory fails in other respects. As noted in §1.5, Chomsky and Halle introduce another convention associated with markedness (SPF:419ff), the convention that the output of phonological rules is 'linked' to the marking conventions. This principle obviates the need to list all the changed feature-values on the right hand side of a rule; rather, any features which are dependent on the value of another feature for their markedness specifications are automatically assigned the unmarked values for those features. Thus, certain feature-values are automatically changed by the linking convention applying to the output of a rule. Consider, for example, the rule cited by Chomsky and Halle (SPF:430), which changes /t' d/ to [s z] before a dental stop in Modern Russian, a rule which they formulate as (2.32):

\[
(2.31) \quad [\text{round}] \rightarrow \begin{cases} 
[\text{aback}] / [-\text{low}] & (a) \\
[-\text{round}] / [+\text{low}] & (b) 
\end{cases}
\]
The output of the rule, which, in the absence of linking, would be [θ ð] in the Chomsky and Halle framework, is linked to two marking conventions, reproduced as (2.33) and (2.34):

\[(2.33) \quad [+\text{cont}] \rightarrow [+\text{del rel}]\]

\[(2.34) \quad [u \text{strid}] \rightarrow [\text{astrid}] / \begin{bmatrix} \text{+del rel} \\ [+\text{ant}] \\ [+\text{cor}] \end{bmatrix}\]

The output of (2.32) is assigned the value [+del rel] (i.e. [+delayed release]) as a result of (2.33), and the value [+strid] as a result of (2.34). Application of the two marking conventions, then, gives (2.35) as the output of (2.32):

\[(2.35) \quad [+\text{ant}] \\ [+\text{cor}] \\ [-\text{nas}] \\ [+\text{cont}] \\ [+\text{del rel}] \\ [+\text{strid}]\]

i.e. the desired [s z].

Cases like these present no problems for the linking principle, in that the recurrent output of the phonological rule is indeed the unmarked output. However, there exist phonological processes in which the output is marked with respect to the conventions.

Lass and Anderson (1975: App. IV) discuss the history of front round vowels in Northern English, and notice that, contrary to what we might expect from the SPE conventions, there appear to be as many changes in this area in which unmarked vowels become marked for a particular value as there are changes in which marked vowels become unmarked. They notice the following changes (1975: 289):
(2.36) \[ \begin{array}{l}
\text{Change} \\
(a) \quad \tilde{\vartheta} \quad \tilde{\varphi} \\
\quad \tilde{\imath} \quad \tilde{\imath}, \quad \tilde{\epsilon} \quad \tilde{\epsilon} \\
(b) \quad \tilde{\sigma} \quad \tilde{\gamma} \\
(c) \quad \tilde{\gamma} \quad \tilde{\eta} \\
(d) \quad \tilde{\sigma} \quad \tilde{\varphi}, \quad \tilde{\tau} \quad \tilde{\tau} \\
\end{array} \quad \text{Direction} \\
m \rightarrow u \\
\end{array} \]

A change such as (2.36d) presents problems for the SPE marking conventions. (2.37), linked to the appropriate conventions, will fail to produce the desired output:

(2.37) \[
\begin{bmatrix}
V \\
+\text{back} \\
+\text{round} \\
-\text{high} \\
\end{bmatrix} \rightarrow [\text{-back}]
\]

The output of this rule is, in the absence of linking, the desired segment (2.38):

(2.38) \[
\begin{bmatrix}
V \\
-\text{back} \\
+\text{round} \\
-\text{high} \\
\end{bmatrix}
\]

i.e. [\tilde{\vartheta}] and [\tilde{\omega}] respectively. However, as the output is automatically linked to the marking conventions, in particular, to convention (2.30), which will change the value for roundness to '-' (the unmarked value for front and low vowels), the outputs will become [\tilde{\vartheta}] and [\tilde{\omega}] respectively. To avoid this, we must override the marking convention by specifying the appropriate value for [round] on the right hand side of the rule, as in (2.39):

(2.39) \[
\begin{bmatrix}
V \\
+\text{back} \\
+\text{round} \\
-\text{high} \\
\end{bmatrix} \rightarrow [\text{-back}, \text{+round}]
\]

Thus (2.39) will be rated as less natural, and more costly to the grammar, than (2.37), as it involves the specification of an additional feature.
If (2.39) did indeed represent an unnatural process, or at least a less natural process than one in which front unround vowels were the output, this would be an acceptable consequence of the theory. However, this is not the case. In §1.5 I considered the case of OE i-umlaut, a process which involves the following changes, among others:

\[
\begin{align*}
(2.40) & \left\{ \begin{array}{l}
\bar{u} \rightarrow \bar{v} \\
\bar{o} \rightarrow \bar{e}
\end{array} \right\} / C_0 [i]
\end{align*}
\]

(2.40), like (2.36d), is a change in which the linking principle has to be overridden by specifying [+round] in the output of the rule, as in (2.41):

\[
(2.41) \left[ \begin{array}{l}
V \\
\text{[+back]} \\
\text{[+round]}
\end{array} \right] \rightarrow \left[ \begin{array}{l}
\text{[+back]} \\
\text{[+round]}
\end{array} \right] / C_0 \left[ \begin{array}{l}
\text{[-back]} \\
\text{[-round]}
\end{array} \right]
\]

and so (2.41) - the formalisation of (2.40) - is rated as more costly than the rule formalising the change in (2.42):

\[
(2.42) \left\{ \begin{array}{l}
\bar{u} \rightarrow \bar{t} \\
\bar{o} \rightarrow \bar{e}
\end{array} \right\} / C_0 [i]
\]

However, (2.40) is a recurrent, natural process, which can be observed in many phonological processes such as OE i-umlaut. The fact that the outputs of similar processes are typically front round vowels suggests that the marking conventions are making an incorrect prediction here. (2.42) is not a more natural process than (2.40), although its formulation in terms of the linking principle would suggest that it is.

This is clearly due to the problem discussed in §1.5 - the failure in SPE to distinguish between naturalness of class and naturalness of process. Although [y] may be generally more marked than [i], it is nevertheless the expected output of a change such as the OE i-umlaut of [u]. The process is a natural one - a fact which cannot be captured within the Chomsky and Halle system.
Kloeke (1980), working within a similar framework, proposes a solution to the problem of the specification of the output of the i-umlaut process. Following Kean (1980), he proposes that there are two kinds of features; m-obligatory features and u-obligatory features, and that the linking principle does not apply to m-obligatory features. These are the features for which "there exists at least one segment which is marked for that feature in the segmental system of a language" (Kean 1980:36). The feature [labial], which Kloeke uses to distinguish [i] from [y], is such a feature; hence the marking convention discussed above does not apply, leaving [y] as the output, and hence "umlaut, a rather fervently debated issue in the past, receives a plausible treatment" (Kloeke 1980:35). It seems, however, that what we have here is another externally imposed convention which increases the complexity of the notational apparatus - there seems to be no inherent formal reason in the distinctive feature notation for, say, [labial] and [low] to be m-obligatory features, while [continuant] and [high] are not. (For a fuller discussion of these proposals, see Kean 1980.)

The preceding discussion shows that the SPE marking conventions have to be rejected as a means of accounting for the 'intrinsic content' of features. Where they make the correct predictions, as we have seen, this is due to the fact that they are designed to do just this, but there are still a large number of cases in which they fail even to do this, due to the failure to make the basic distinction between the two kinds of naturalness.

A solution to this latter problem is offered by Schachter (1969:346), who notes that "markedness is relevant not merely to the output of the P-rules but to the functioning of these rules as well". He notices further that of the two equally simple rules (2.43) and (2.44), (2.43) is a recurrent rule, while (2.44) is not:

\[
(2.43) \quad \begin{array}{c}
-voc \\
+cons
\end{array} \rightarrow [+voiced] / \begin{array}{c}
+voc \\
-cons
\end{array} [+] [+] \\
(2.44) \quad \begin{array}{c}
+voc \\
-cons
\end{array} \rightarrow [-voiced] / \begin{array}{c}
-voc \\
+cons
\end{array} [-] [-]
\]
i.e. consonants frequently assimilate in voicing when intervocalic, but vowels do not assimilate in voicelessness when interconsonantal. He proposes the introduction of a further feature specification $N$, so that phonological rules may have the form:

\[(2.45) \ A \rightarrow Nf / X \quad Y\]

where "$f$ is any feature, and $N$ is the metatheoretically specified natural value for that feature in the context $X \quad Y" \ (1969:348). Thus, the metatheoretically established naturalness conditions would presumably replace [+voiced] in (2.43) by $[N$ voiced] (a costfree entry in the grammar), making (2.43) less complex than (2.44), which would remain unaltered.

However, even if Schachter's proposals achieve the object of distinguishing natural from non-natural processes, they have exactly the same status as Chomsky and Halle's markedness proposals, in that they, too, represent externally imposed elaborations of the theory, whose sole function is to remedy the deficiencies inherent in the nature of distinctive feature notation - specifically, deficiencies in distinguishing naturalness from non-naturalness, which, we shall see in the chapters that follow, is largely due to the lack of structure (in the sense of §1.1) of the feature matrices.

An area of difficulty related to the above is exemplified by the SPE features [high] and [low]. We saw in (2.4) that the conjunction [+high, +low] cannot occur, because of the way in which the features are defined. However, there is no formal reason within the binary feature framework to expect the non-occurrence of this combination; [+high, +low] is formally no different from the (occurring) combination [-high, -low]. Chomsky and Halle (SPE:405) propose the following marking convention for [+low] segments:

\[(2.46) \ [+low] \rightarrow [-high]\]

and observe that "this is but another way of expressing the fact that the feature in question is not subject to marking and will therefore always remain unmarked". However, Kean (1980-28-29) observes that
"there is something seriously wrong with a theory that does not predict that [+low] segments will be [-high]", and proposes, instead of the use of marking conventions for cases such as this, the introduction of a set of 'implications'. These implications are meant to block the occurrence of matrices containing such 'contradictory' (i.e. phonetically impossible) specifications, and hence "capture the coocurrence restrictions on feature specifications". This avoids the possibility of a segment such as /a/ being [mhigh]; this is undesirable in that it suggests "that there could be a segment like /a/ in all respects except that it is [uhigh]". The particular implication proposed for vowel height is:

(2.47) [+low] \rightarrow [-high]

However, the need to have (2.47) (or indeed (2.46)) is clearly a consequence of characterising the single phonetic parameter of vowel height by two binary features. Whenever this situation holds (i.e. where the features characterise 'opposite' properties on the parameter in question), one of the four formally possible feature specifications will be non-occurring, and, in Kean's model, subject to an implication such as (2.47). Such implicational rules, then, represent yet again an attempt to cover up a formal deficiency in the model; what should be inherent to the system of representation is characterised by an externally imposed convention.
Chapter 3

Notational Systems 3: Other Models

In this chapter I will be concerned with some notational systems which do not take the distinctive feature as the basic phonological element. In most of these models, unlike those discussed in chapter 2, the segment is not viewed as an unordered set of ordered pairs consisting of a feature-value and a feature-name. Rather, the segment has a rather different internal structure, and indeed in some proposals we shall see that the concept of the segment is no longer part of the phonological representation. In certain of these models, too, we shall see that proposals are made concerning the structure of sequences of segments; proposals which again involve the postulation of a greater degree of structure than is apparent within the SPE theory. The models which I shall consider all contain notions which are in some way relevant to the theory of dependency phonology to be developed in the following chapters.

3.1 Natural phonology

I begin by looking at a set of proposals in which the notion of the segment is retained, but in which the internal structure of the segment is given a rather different treatment than in the various distinctive feature theories discussed in chapter 2. This is the notion of representation associated with the theory of natural phonology, which has been developed in a number of places, notably in Stampe (1972, 1979) and in Donegan and Stampe (1978, forthcoming). One of the most important aspects of natural phonology has been the phonological characterisation of the vowel space - see [Donegan] Miller (1973), Donegan (1976, 1978).
It will be recalled from chapter 2 that Chomsky and Halle characterise the dimension of vowel height by means of two binary features [high] and [low]. Two other binary features are proposed in SPE for the representation of the other dimensions in the vowel space - [back] and [round]:

Back sounds are produced by retracting the body of the tongue from the neutral position; nonback sounds are produced without such a retraction. (SPE:305)

Rounded sounds are produced with a narrowing of the lip orifice; nonrounded sounds are produced without such a narrowing. (SPE:307)

The four features allow a characterisation of the vowel space as in (3.1):

```
(3.1) [-back]   [+back]
     [-round]   [+round]   [-round]
[+high, -low]   i   y (ũ)   u   w (ʍ)
[-high, -low]   e   φ (ɔ)   o   ø
[-high, +low]   ø   ø (œ)   œ
```

Each vowel, then, may be characterised (in the area under discussion) as an unordered set of feature-values as in (3.2):

```
(3.2) φ (ɔ)  w (ʍ)  ø  æ
     [-high]  [+high]  [-high]  [-high]  [-high]
     -low   -low  +low
     -back  +back  -back
   [round]  [-round]  [round]
```

Each matrix is apparently formally identical - the only variable being the feature-values. Chomsky and Halle's notational system may be said to be 'minimally componential' (cf. the discussion of componentiality in §1.1), in that the only way in which segments can differ from each other is in the values they bear for the various features, and, further, in that there is no sub-grouping of features within the set of features characterising each segment. In short, there is no structural variable in a distinctive feature matrix (whether binary or multivalued), other than the values of the features.

This property of distinctive feature matrices means that the
notion of relative complexity referred to in §1.7 cannot be accounted for by the theory, except by appeal to the theory of markedness discussed in §2.4.1. As markedness theory was shown to be inherently circular, and therefore had to be rejected, distinctive feature theory has no metric for measuring phonological complexity.

The notational system of natural phonology differs in various respects from that of distinctive feature theory. Within this model, instead of the four features of (3.2), three 'cardinal properties' are established: palatality, labiality, and sonority ([Donegan] Miller 1973:386). Palatality and labiality are chromatic properties, "optimized by a minimally open, maximally constricted vocal tract", while sonority "is optimized by a more open vowel tract". Donegan claims that the familiar vowel triangle represents the maximal opposition of the three properties:

(3.3) i
   \[\alpha\]
   \[u\]

[i] and [u], then, show a property, 'colour', which [\alpha] lacks. Palatality, "associated with tongue fronting, high second formant values, and high intrinsic pitch", and labiality, "associated with lip rounding, low second formant values, and low intrinsic pitch", represent one of two conflicting qualities - i.e. colour - opposed to the other - sonority. More sonorant vowels have a higher first formant than less sonorant ones, and have a higher overall intrinsic intensity (Donegan 1976:146, 1978:35). These two qualities - colour and sonority - are "phonetically incompatible" - the more sonorant a sound, the less chromatic it is, and vice versa. [\alpha] - the most sonorant vowel - is achromatic (lacking palatality and labiality), while [i] and [u] have relatively low sonority. Vowels which are not at the extremes of the triangle appear to be intermediate as far as these properties are concerned; thus we find ([Donegan] Miller 1973:386):
Ordinarily, the more sonorant a vowel is, the less color it has; and the more chromatic it is - the less sonorant. Thus, while i, e, and a are all palatal, i is more palatal than e, and e is more palatal than a; and, similarly, the degree of rounding varies for u, o, o. The vowels i, a, and a are colorless or achromatic. They lack both palatality and labiality, and differ only in sonority.

Donegan (1978:44) claims that the use of a single term to cover palatality and labiality is justified, in that:

Palatal and labial vowels frequently undergo parallel substitutions or condition substitutions in parallel ways, and... non-palatal non-labial vowels often undergo or condition substitutions that 'chromatic' vowels do not.

It appears, then, that the proponents of natural phonology consider vowel properties to be characteristics which can be present or absent, or be present in various degrees. As we have seen, [a] is said to lack palatality and labiality, while [i] and [u] have 'relatively low' sonority, and we might expect this to be reflected in the notation. However, no formal mechanism for representing vowels, in particular different vowel heights, is provided. The kind of representation used is illustrated in (3.4) (from Donegan 1976:146):

(3.4)  
<table>
<thead>
<tr>
<th>-chromatic +chromatic</th>
</tr>
</thead>
<tbody>
<tr>
<td>-palatal +palatal</td>
</tr>
<tr>
<td>-labial +labial</td>
</tr>
<tr>
<td>(-tense) -tense +tense</td>
</tr>
<tr>
<td>high i i</td>
</tr>
<tr>
<td>mid a a</td>
</tr>
<tr>
<td>low o o</td>
</tr>
</tbody>
</table>

Donegan, then, envisages a non-binary feature of vowel height, rather than a binary feature representation; indeed, she notes (1978: 36-37) that the acoustic correlates of sonority are clearly scalar, and that phonological evidence, too, suggests a scalar interpretation. However, as far as the various vowel properties are concerned, the formalism of (3.4) seems at odds with the concepts discussed above. The feature notation used obscures the claims of natural phonology that chromaticity and sonority are in an inverse, apparently scalar relationship. (3.4) does not show that as a vowel becomes more sonorant, it becomes less chromatic, and vice versa. Nor does
it show, except to the extent that the binary feature-value '-1 is used, that [o] is achromatic. As in the Chomsky and Halle system, the notation fails to allow for the possibility of any structural variables other than feature-value.

That this failure is, indeed, a drawback for the natural phonology model is apparent from the various 'natural processes' which are discussed by [Donegan] Miller (1973). She defines two of these natural processes - bleaching and colouring. "In this framework, the terms bleaching and coloring are almost self-explanatory: bleaching removes color, and coloring adds color." (1973:386). Bleaching, then, is manifested as the removal of either palatality or labiality, or both simultaneously, i.e. the removal of either or both of the chromatic properties. So changes such as [y]→[i], [u]→[+] involve bleaching by removal of the labiality colour; while [y]→[u], [i]→[+] are bleaching by removal of the palatality colour. Colouring is manifested by "two distinct processes" - palatalisation and labialisation (rounding). Changes such as [i]→[y] or [u]→[y], then, are colouring processes.

[Donegan] Miller characterises bleaching and colouring as having opposite causalities, which together have the tendency to "polarize or optimize the properties of individual segments". Thus, more sonorant vowels tend to lose colour and increase sonority; less sonorant vowels tend to develop a colour, "which increases their distinctiveness". Notice that [Donegan] Miller, in considering the conditions which favour each of these changes, is dealing with context-free processes. She notes (1973:388) that "like other context-free processes, bleaching and coloring are paradigmatically motivated - i.e. they tend to polarize or optimize the properties of individual segments".

Because of this basic causality, there are various conditions on the applicability of each process. Thus, bleaching is more likely to affect low vowels than high vowels, because of the general condition on applicability that "the less color a vowel has, the more likely it is to bleach". Low vowels already have a lower degree of chromaticity than high vowels, and this bleaching makes them even
less chromatic - a change such as \([a] \rightarrow [a]\) (using Donegan's symbols of (3.4)), then, is rated as highly likely, involving as it does the removal of the palatality colour to give a non-palatal and non-labial (hence achromatic) vowel. Such a change is therefore more favoured as a bleaching process than, say, the depalatalisation or delabialisation of high vowels. Thus, \([y] \rightarrow [u], [y] \rightarrow [i], [y] \rightarrow [i],\) involving respectively bleaching by depalatalisation, by delabialisation, and by both depalatalisation and delabialisation, are less favoured than the corresponding bleaching of the mid vowels in the changes \([\ddot{a}] \rightarrow [o], [\ddot{e}] \rightarrow [e], [\ddot{e}] \rightarrow [\ddot{a}].\) [Donegan] Miller cites the fact (from Campbell 1959: 76-77, 132) that unrounding of OE \(\phi\) preceded unrounding of OE \(\gamma\) as support for these claims (see also 1978: 85, for other, similar, data).

Further, bleaching favours 'mixed' vowels rather than pure vowels. Mixed vowels are those containing both colours, while pure vowels are those with just a single colour. Thus, changes such as \([y] \rightarrow [i]\) and \([y] \rightarrow [u]\), involving the removal of one colour from the mixed vowel \([y]\) are favoured over changes such as \([u] \rightarrow [i]\) and \([i] \rightarrow [i]\), involving the same bleachings, but this time affecting vowels which have only a single colour, and whose properties are therefore already maximally polarised. This has a perceptual motivation; thus Donegan (1978: 47) notes:

If [lip-rounding and tongue-fronting occur simultaneously], they attenuate each other's acoustic effects, so that they are, at least perceptually, less labial than pure labials and less palatal than pure palatals.

They are thus 'marked' or non-optimal; they tend to become monochromatic, and they are consequently rarer in the phoneme inventories of the world than pure labials or pure palatals.

We might expect that the conditions favouring bleaching - i.e. the general causality underlying all context-free changes - should be in some way reflected in the notation used. This does not seem to be the case, however. Donegan (1978: 83) provides the following general rule-schemata for bleaching:
(3.5) 

\[
\begin{array}{c}
V \\
\text{lower} \\
\text{-tense} \\
\text{mixed} \\
\text{/} V \\
\text{+labial} \\
\end{array}
\rightarrow \text{[-labial]}
\]

(3.6) 

\[
\begin{array}{c}
V \\
\text{lower} \\
\text{-tense} \\
\text{mixed} \\
\text{/} V \\
\text{+palatal} \\
\end{array}
\rightarrow \text{[-palatal]}
\]

(3.5) and (3.6) use the convention of the exclamation mark to show that a particular category will favour application of the process. Thus '!lower' means that bleaching favours lower rather than higher vowels, and similarly lax over tense, and mixed over pure.

Further, Donegan (1978: 88) notes:

Vowels are particularly susceptible to bleaching when they appear in like-colored environments — i.e., labials are particularly susceptible to bleaching before or after labials, and palatals are particularly susceptible to de-palatalization before or after palatals.

As I am at present only considering the characterisation of the vowel space, I ignore from now on the laxness and environmental conditions.

The need to have such schemata reflects the lack of an appropriate notational system associated with the theory of natural phonology. If bleaching is indeed more natural for mixed vowels than for pure vowels, we should expect our system to reflect this, and indeed to reflect the difference between 'mixed' and 'pure' vowels in the first place. However, consider now some particular instantiations of (3.5) and (3.6), using the symbols of (3.4):

(3.7) 

\[
\begin{array}{c}
[y] \\
\text{+chrom} \\
\text{+pal} \\
\text{+lab} \\
\text{high} \\
\end{array}
\rightarrow \begin{array}{c}
[u] \\
\text{+chrom} \\
\text{+lab} \\
\text{high} \\
\end{array}
\]

(3.8) 

\[
\begin{array}{c}
[i] \\
\text{+chrom} \\
\text{+pal} \\
\text{-lab} \\
\text{high} \\
\end{array}
\rightarrow \begin{array}{c}
[i^+] \\
\text{-chrom} \\
\text{-lab} \\
\text{high} \\
\end{array}
\]
There is no formal indication in (3.7)-(3.10) of the claims of natural phonology - there is no way of showing whether a vowel is mixed or pure, or of showing that bleaching of a low vowel is more to be expected than bleaching of a high vowel. In turn, there appears to be no way of representing the notion of relative complexity, a notion which seems inherent to natural phonology: if mixed vowels are more susceptible to bleaching, and this is associated with their being more complex than pure ones, on the grounds discussed in §1.7, the natural phonologist can only express this metathecetically - it does not arise out of the notation used.

Exactly the same observations apply to the colouring process, which, being the reverse of bleaching, favours opposite conditions of applicability. Thus, higher vowels tend to colour before lower vowels. As low vowels are maximally sonorant and minimally chromatic, the addition of a colour would reduce their distinctiveness. Similarly, colouring affects only achromatic vowels. The colouring of an already chromatic vowel - i.e. the addition of a colour to a vowel which already has the other colour - would reduce its distinctiveness (by attenuating the acoustic property associated with the colour which it already has), while the addition of a colour to an achromatic, non-sonorant vowel increases its distinctiveness, and is therefore to be viewed as a natural process. Thus the context-free colouring of [ɨ] to [u] by labialisation or to [ı] by palatalisation is to be expected, and is more natural than the colouring of a lower vowel such as [ʌ] to [ɔ] or [ɛ], while context-free colouring of [u] or [i] to [γ] is non-natural, as it reduces the distinctiveness of the vowel.

As with bleaching, no motivation for the process can be discovered from the notational system - the only motivation which is offered is externally imposed. In general, we can say that the insights of natural phonology are not reflected in its notational system. In
particular, the system fails to reflect in any way "the degree of property which a segment possesses" ([Donegan] Miller 1973:388), which, she claims, must be referred to in offering phonetic explanations for the processes of bleaching and colouring.

In a later chapter, I shall show that the principles behind natural phonology do, in fact, need to be taken into account in establishing a system of phonological representation. That is, the notions of the three cardinal properties, and of mixed and pure vowels, are appropriate, and I shall show that the theory of dependency phonology is able to characterise them in such a way as to overcome the lack of an adequate notational system associated with natural phonology.

3.2 Prosodic analysis

In this section I shall discuss briefly the theory of prosodic analysis associated with 'the London school' of the forties and fifties. The principles of the theory are discussed in Firth (1948) and Robins (1957), and various phonological systems are analysed in terms of this model in other papers in Palmer (1970).

The aim of the theory is summarised by Robins (1957:191) as:

a phonological analysis in terms which take account not only of paradigmatic relations and contrasts, but also of the equally important syntagmatic relations and functions which are operative in speech.

That is to say, prosodic analysis (unlike phonemic analysis, which, in various forms, was the most widely accepted model of phonological representation at the time) does not consider words and morphemes to be made up of a string of discrete segments, but, rather, to be made up of two different types of unit. These two types of element are the prosodies and the phonematic units.

Phonematic units are the units which are segment-sized - they "refer to those aspects of the phonemic material which are best regarded as referable to minimal segments, having serial order in relation to each other in structures" (Robins 1957:192). However, a structure is not just a string of these minimal segments, but is also
defined by the other aspects of the phonetic material - those aspects which are referable to prosodies. The prosodies have as their domains stretches of more than one segment, and may belong to structures of any length. Structures, then, are units such as syllables, morphemes, words, sentences, etc., and associated with each of these structures there may be particular prosodies. Syllable prosodies might include stress and tone, while intonation would be a sentence prosody. Thus the prosodist claims that phenomena such as stress and tone cannot, phonetically, be associated uniquely with a single segment, but rather must be associated with a sequence of segments, and this is reflected in the notation which they develop. Similarly, in languages in which one particular segment-type is invariably followed by another segment-type displaying the same phonetic characteristics - e.g. languages in which a nasalised consonant is always followed by a nasalised vowel - such sequences will also be analysed as containing prosodies of 'syllable parts'. In this case, nasalisation will be abstracted as a prosody whose domain is the stretch CV. This kind of treatment is not available to the SPE-type phonologist, for whom all morphemes are made up of discrete segments characterised by feature-matrices. In SPE, stress, for example, is treated as a property of the vowel, and not of a unit longer than the segment.

However, prosodies are not necessarily confined to traditional suprasegmentals such as these. One area which has been much discussed by the prosodists is that of vowel harmony. Lyons (1962), in a paper discussing the merits of prosodic analysis, considers the problem of vowel harmony in Turkish, and I shall examine here the principles which he uses in setting up a prosodic analysis of this phenomenon.

Turkish is a language with eight vowel phonemes, all of which occur contrastively in monosyllables, as in (3.11), where I also give an SPE-type feature assignment of these segments:

(3.11) | [-back] | [+back] |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>[-round]</td>
<td>[round]</td>
<td>[-round]</td>
</tr>
<tr>
<td>[+high]</td>
<td>l</td>
<td>y (ü)</td>
</tr>
<tr>
<td>[-high]</td>
<td>e</td>
<td>ş (ı)</td>
</tr>
</tbody>
</table>
In monosyllables, then, there are two contrastive degrees of height, backness, and roundness. In polysyllabic words, however, the vowel harmony processes apply. There is no restriction on the co-occurrence of high and low vowels in the same word. However, front vowels and back vowels cannot cooccur in one word, nor can rounded and unrounded vowels. There is one exception to this – if the vowel of the first syllable is low and rounded, the vowels of succeeding syllables are unrounded.

Thus, in any one word, only two different vowels can occur – any pair of high and low vowels showing the same backness and roundness characteristics, as in (3.12), which uses the phonemicisations found in Lyons (1962:131):

(3.12) a. /kibritim/ 'my match' b. /gülüm/ 'my rose'
   /evler/ 'houses' †/gözler/ 'eyes'
   /kibritler/ 'matches' /gözum/ 'my eye'
c. /bulutum/ 'my cloud' d. /kızım/ 'my daughter'
   /kolum/ 'my arm' /adamlar/ 'men'
   †/kol lar/ 'arms' /kızlar/ 'daughters'

(The forms marked † are those whose non-initial vowels are determined by the exception to the general rule mentioned above.)

However, as Lyons points out, the phonemicisation of (3.12) suggests that the vowels in polysyllabic words are in parallel distribution in all places in the structure, i.e. that there is a free choice amongst all eight Turkish vowel phonemes. This is not the case, however, because of the vowel harmony constraints. The only free choice is between high and low vowels; the other phonetic characteristics are common to all the vowels in the word. In a prosodic analysis of the Turkish vowel harmony phenomenon, then, it is appropriate to set up two word prosodies – a front/back prosody and a rounding/non-rounding prosody, which Lyons represents as F:B and R:N respectively. These prosodies, then, have the word as their domain, and will determine the appropriate rounding and backness characteristics of all the vowels in the word. Because high and low vowels
are in phonematic contrast, we can set up two phonematic units, which
Lyons represents as i:a. The representations of the words in (3.12)
become, in this prosodic treatment:

(3.13) a. FNkibritim  b. FRgilim
   FNavlar  +FRgazlar
   FNkbritlar  FRgazim
c. BRbiltim  d. BNkizim
   BRkalim  +BNadamlar
   +BRkallar  BNkizlar

where the prosodies are placed (for convenience) before the word, and
link up with the phonematic units to give the appropriate surface
vowel. (Notice, however, that the nature of this linking up process
is not explicitly formulated.) In the cases where the prosody is R
and the first phonematic unit a, any following a combines with N, to
give /a/ and /e/ rather than /o/ and /Ø/.

It can be seen that the prosodic approach captures aspects of
phonological structure which are not accessible to standard distinc-
tive feature theory. Essentially, the adoption of a two-dimensional
approach, in which words are not made up merely of sequences of un-
ordered sets, enriches the structure in a way which allows a more
satisfying account of vowel harmony than is available to feature
theory. In order to capture the generalisations inherent in the rep-
resentations in (3.13), Ringen (1975:50, 57) proposes the following
two rules (adapted from Lightner 1972):

(3.14) Backness harmony

V → [a\text{back}] / [\text{a\text{back}}] C_0

(3.15) Roundness harmony

V → [a\text{round}] / [\text{a\text{round}}] C_0

In Ringen’s model, the predictable features of backness and
roundness are unspecified for all vowels except the first in a root.
Thus, the forms in (3.12) would have underlying representations such as the following:

\[(3.16) \quad /kibr\text{It} + IAr/ \quad /g\text{ül} + Im/ \]
\[/bul\text{It} + Im/ \quad /kTz + IAr/ \]

Notice that (3.14) and (3.15) will apply iteratively in words of more than two syllables - after the vowel in the second syllable has been assigned the appropriate feature-values according to the values of the vowel in the first syllable, the rule must reapply to assign the appropriate values to the third vowel, on the basis of the values of the second vowel. Thus, (3.17) shows the derivation of /bulutum/ in a feature-based model such as Ringen's:

\[(3.17) \quad /bul\text{It} + Im/ \]

\[
\begin{array}{c}
\text{Backness harmony} \\
\text{Backness harmony} \\
\text{Roundness harmony} \\
\text{Roundness harmony}
\end{array}
\]

\[
\downarrow \\
\downarrow \\
\uparrow \\
\downarrow
\]

\[
\text{\text{u}} \\
\text{\text{u}}
\]

It can be seen that the feature framework is a rather clumsy notational device for the purpose for which it is used here. It suffers from two principal drawbacks. Firstly, it implies that vowel harmony is a process which is dependent on the quality of the first vowel in a word, and which operates between successive vowels. Secondly, it obscures the fact that vowel harmony appears to be a property of the word as a whole, rather than of individual vowels. The prosodic notation shows frontness and roundness to be properties of the whole word, while the feature notation of SPE obscures this.

(Notice, however, that the prosodic notation fails to indicate that the prosody is manifested only on vowels, and not on consonants; further, as noted above, it remains unclear how the prosodies combine with the phonematic units to give phonetic representations.)

3.3 Autosegmental phonology

I want now to turn to some aspects of the theory of autoseg-
mental phonology. This model has been developed in Goldsmith (1976a, 1976b), and, as far as the treatment of vowel harmony is concerned, in Clements (1977). The notational system used in this theory appears to derive from that used by the prosodists, although, as we shall see, it is used within a rather different theoretical framework.

Like the model of prosodic analysis, the model of autosegmental phonology differs from the distinctive feature frameworks of chapter 2 in that not all phonological units are the size of the traditional segment. Specifically, while words are made up at one level of segments of the traditional kind, there are also other levels at which we find segments of different length. These may be longer or shorter than usual segments, and are the autosegments. These autosegments correspond for the most part to suprasegmentals such as tone, stress, and pitch.

Goldsmith (1976a:17ff) illustrates this claim with the English monosyllable <pin>. In an SPE theory, "the linguistic representation of the word consists of three segments linearly ordered", as in (3.18):

\[
\begin{array}{ccc}
+\text{conson} & +\text{syllabic} & +\text{conson} \\
-\text{nasal} & -\text{labial} & +\text{nasal} \\
+\text{labial} & -\text{coronal} & -\text{labial} \\
-\text{coronal} & \cdot & +\text{coronal} \\
\cdot & \cdot & \cdot \\
\cdot & \cdot & \cdot \\
\cdot & \cdot & \cdot \\
'p' & 'i' & 'n'
\end{array}
\]

Goldsmith notices that the word <pin> uttered in isolation will be produced with a rapidly falling pitch, which he represents as a sequence of a High pitch and a Low pitch. If, then, we want to indicate the pitch in our feature-matrix, certain problems present themselves. Although we can segment the pitch pattern into a sequence of H followed by L (where H is high pitch and L low pitch), this segmentation does not correspond in any way to the segmentation of the items in (3.18). Thus, in Goldsmith's terms, the 'Absolute Slicing Hypothesis', i.e. the hypothesis that the word can be divided verti-
cally into the same segments at all levels of analysis, fails, because a property such as pitch in English is a property not of a single segment, but of a sequence, and as such, may itself show internal segmentation which differs from the segmentation at other levels. (3.19), then, displays this:

(3.19) \[
\begin{array}{ccc}
+\text{conson} & +\text{syllabic} & +\text{conson} \\
-\text{nasal} & -\text{nasal} & +\text{nasal} \\
+\text{labial} & -\text{labial} & -\text{labial} \\
-\text{coronal} & -\text{coronal} & +\text{coronal} \\

[+\text{high}] & [-\text{high}] & [-\text{high}] \\
[-\text{low}] & [+\text{low}] & [+\text{low}]
\end{array}
\]

where the first level (the first of the 'autosegmental tiers') is the 'phonological level', and the second the 'tonological level'. Tone, then is represented as being a property of the whole sequence, and not of the vowel alone.

Goldsmith argues that these notions cannot be adequately incorporated into the SPE model. He considers, for example, the case of 'contour tones' in tone languages, i.e. falling tones and rising tones, which, in his interpretation consist of a high tone followed by a low tone, and a low tone followed by a high tone respectively. If tone is a property of the vowel, as Chomsky and Halle would claim, this presents problems for their notational system, in that a single vowel must be assigned two (sequentially ordered) tones. Goldsmith suggests two possibilities for an SPE-type representation:

(3.20) \[
\begin{array}{ccc}
+\text{syllabic} \\
+\text{constricted} \\
+\text{pharynx} \\
-\text{high} \\
-\text{round} \\
+\text{Highpitch} \\
-\text{Lowpitch} \\
-\text{Highpitch} \\
+\text{Lowpitch}
\end{array}
\]
where (3.20) and (3.21) both represent /a/ with a falling tone, i.e. a sequence of a high tone and a low tone, represented by Goldsmith as /å/. In the case of (3.20), some notion of vertical ordering must be incorporated to account for the sequential ordering of the tones, and (3.21) involves a claim that there can be sequential ordering within a single segment. Neither possibility is found in the distinctive feature notational system as presented in SPE. (For further discussion of the notion of sequential ordering within the segment, see §7.4.)

Goldsmith therefore abandons the notion that tonal features are features of vowels (1976:23):

Rather, the tonal features are factored out to another level; feature specifications on the other level constitute segments, but their relation to the vowels with which they are associated is merely one of simultaneity in time. We represent this dynamic element by association lines:

(3.22) 

Where appropriate, other autosegmental tiers like the two in (3.22) would be present in the representation of a word. Thus a word (or a larger unit) might consist of a set of such autosegmental tiers, each of which might be segmented at different points, as in (3.23):
Like the prosodic analysis of §3.2, the concept of the autosegment may also be used with respect to processes such as vowel harmony. Instead of a prosody such as we found in the account of Turkish vowel harmony, we find in the autosegmental model a 'harmonic autosegment', whose function appears much the same. Goldsmith considers some data from the vowel harmony system of Igbo which illustrates this approach. Igbo has two sets of vowels which differ in the value they have for the feature [Advanced Tongue Root] ([ATR]):

\[(3.24) \quad \text{i e u o } \quad \text{! a y o } \quad \begin{array}{c} [+\text{ATR}] \quad [-\text{ATR}] \end{array} \]

Within certain domains of the word in Igbo, all vowels must agree in the value which they have for the feature [ATR]. Goldsmith suggests that the value [+ATR] forms a harmony autosegment, which operates on a different harmonic tier, as in (3.25):

\[(3.25) \quad \text{CV CV CV CV} \quad \begin{array}{c} \text{[+ATR]} \end{array} \]

Each vowel is associated with the autosegment [+ATR], whose domain is the whole word, and so the notion of vowel harmony as a property of the word is given a formalisation.

Goldsmith suggests that the concept of the feature [ATR] as an
autosegment enables the natural representation of certain deviant aspects of vowel harmony in Igbo. Thus, certain suffixes block vowel harmony, and impose their own vowel harmony on any following vowels. The Igbo suffix /sI/ operates in this way, as in (3.26):

\[
\begin{array}{c}
(3.26) \\
\text{prefix stem suffix suffix suffix}
\end{array}
\]

\[
\begin{array}{c}
\# E + vU + tE + sI + ghI \\
\# [+ATR] [-ATR]
\end{array}
\]

(where capital letters denote vowels unspecified for the feature [ATR]). (3.26) is an autosegmental representation of the underlying structure of the 'surface' representation (3.27), which in turn underlies the phonemic representation /evutes|gh/:

\[
\begin{array}{c}
(3.27) \\
\text{prefix stem suffix suffix suffix}
\end{array}
\]

\[
\begin{array}{c}
\# E + vU + tE + sI + ghI \\
\# [+ATR] [-ATR]
\end{array}
\]

As in normal cases, the value [+ATR] is associated with the vowels of the first three syllables (the prefix, stem, and first suffix), but is then blocked because of the [-ATR] specification which is (lexically) associated with the second suffix. This in turn assigns [-ATR] to any suffix following it, to yield the appropriate output.

It is easy to see how this system would apply to the Turkish vowel harmony data considered in §3.2. The features [back] and [round] would operate within autosegments on a different level from the feature [high], to give, for example, (3.28) (in which I leave the internal structure of the consonants unspecified):

\[
\begin{array}{c}
(3.28) \\
\text{prefix stem suffix suffix suffix}
\end{array}
\]

\[
\begin{array}{c}
\# k +V + b r +V + t +V + m \\
\# [-back] [-round]
\end{array}
\]

The autosegmental feature-values would then be associated with
each of the vowels, to give (3.29), and at a later stage deautosegmentalised to give the familiar representation in (3.30):

(3.29) # k [V +high] b r [V +high] t [V +high] m #
     # [ -back] [ -round] #.

(3.30) # k [V +high] b r [V +high] t [V +high] m #
     [ -back] [ -back] [ -back] [ -round] [ -round] [ -round']

The exceptional cases in Turkish vowel harmony, where a low vowel in the first syllable inhibits roundness harmony, might be handled as follows. The underlying autosegmental representation of /gözler/ is given as (3.31):

(3.31) # g [V -high] z l [V -high] r #
     # [ -back] [ +round] #

i.e. the underlying representation is perfectly regular. The association of the values [-high, +round] in the first syllable, however, would trigger a rule (here unspecified) whereby all following [-high] vowels would be associated with a [-round] feature on the harmonic level, to give (3.32):

(3.32) # g [V -high] z l [V -high] r #
     # [ -back] [ +round] [ -round] #

a representation which will later be deautosegmentalised, thus yielding a standard SPE-type representation.

The framework of autosegmental phonology has also been applied to the phenomenon of preaspiration in Icelandic by Thráinsson (1978).
Thráinsson argues that, phonetically, the preaspiration process involves the replacement of the first of two successive voiceless stops by [h]. This is apparent in various sets of alternations, as in (3.33) (from 1978:8):

(3.33)  
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>feit [fei̞:tʰ] 'fat'</td>
<td>feitt [feiht]</td>
</tr>
<tr>
<td>ljót [ljou̞tʰ] 'ugly'</td>
<td>ljött [ljouht]</td>
</tr>
<tr>
<td>sát [saı̞tʰ] 'sweet'</td>
<td>sætt [saıht]</td>
</tr>
</tbody>
</table>

The formation of the neuter singular form of an adjective in Icelandic involves the addition of a suffix /t/. If the stem of the adjective also ends in /t/, giving /tt/, the synchronic rule of preaspiration applies, to give [ht] instead of [t:], as in (3.33).

A similar situation is to be found in the formation of the past tense of a weak verb. The past tense suffix is /ð/, which after voiceless stops and /s/ changes to /t/. If the stem ends in /t/, thus giving a geminate sequence, the preaspiration rule again applies, as in (3.34):

(3.34)  
<table>
<thead>
<tr>
<th>Inf.</th>
<th>Past</th>
</tr>
</thead>
<tbody>
<tr>
<td>møta [mai̞tʰa] 'meet'</td>
<td>møtti [maihtı]</td>
</tr>
<tr>
<td>veita [vei̞tʰa] 'grant'</td>
<td>veitti [veihti]</td>
</tr>
<tr>
<td>nýta [ni̞i̞thaña] 'utilise'</td>
<td>nýtti [nihti]</td>
</tr>
</tbody>
</table>

Thráinsson is concerned with the phonological characterisation of the process. He argues that what is involved is the deletion of some of the phonological features characterising the first of the voiceless stops, specifically, the set of supralaryngeal features. The rule, then, is given as (3.35) (from 1978:36):
The laryngeal features are taken from Halle and Stevens (1971: 203). Thráinsson claims that the difference between /p t k/ and /b d g/ in Icelandic is not one of voicing, but of aspiration, and hence uses the feature [spread glottis] ([SG]) to characterise the difference - /p t k/ being [+SG], and /b d g/ [-SG]. (I return to the matter of aspiration in chapters 7 and 9.) After deletion of supralaryngeal features, what remains are the laryngeal features alone, which, Thráinsson argues, are in this case just the features characterising [h] in the Halle and Stevens model. The supralaryngeal specification of [h], which "reflects the formant structure of the preceding vowel" might, Thráinsson claims, either be characterised by universal convention, or be expressed directly "by adding an association line from the set of supralaryngeal features of the vowel to C₁", as in (3.36):

Thráinsson notices that this analysis incorporates Goldsmith's claim that "autosegmental phonology is a theory of how the various
components of the articulatory apparatus, i.e. the tongue, the lips, the larynx, the velum, are coordinated" (Goldsmith 1976b:23). In this case, then, the autosegments of the theory are the same size as the 'normal' segments, but represent subsets of this segment. In chapter 5, I return to a detailed discussion of the arguments for splitting up segmental representations into such subsets.

It can be seen that the concepts of prosodic analysis and autosegmental phonology are very similar, to the point where their systems of representation might be considered to be notational variants of each other. Indeed, Clements (1977:117) notes:

Autosegmental phonology could be regarded, in part, as an attempt to construct a formal theory capable of expressing some of the insights about prosodic structure which Z. Harris and J. R. Firth shared.

Harris (1944) suggests that there may be components in the phonological structure which are longer than the traditional segment, and calls these components long components. These long components are essentially the forerunners of features which have the property, not found in SPE, of being able "to extend over a number of phoneme places" (1944:192), and are proposed in order to characterise properties shared by sequences of phonemes. A rather similar analysis of vowel harmony phenomena could be offered by using Harris's long components (see, for example, Sommerstein 1977:54). Thus, all three systems share the characteristic of being able to represent the notion of certain phonological features, properties, or whatever extending beyond the limits of a single segment, the phenomenon sometimes known as 'feature smear' or 'spread'. However, I have ignored here, as they are not relevant to the topic of this thesis, many of the ways in which prosodic analysis and autosegmental phonology differ with respect to the theoretical implications underlying the theories. For example, I have not dealt with the prosodists' claim that the phonological components of language are polysystemic (see Sommerstein for discussion), or with Goldsmith's account of how the various autosegmental tiers are to be 'associated' with each other, or with the phonemic principles underlying the Harris long components. For discussion of these matters, the reader is referred to the various items cited in these two sections.
3.4 The hierarchical model

I want now to consider a model which also shows some similarities to the model of prosodic analysis, but differs in certain important ways. This is the hierarchical model developed by Griffen (1975, 1976). Griffen lays great stress on the 'inner approach' of Trubetzkoy (1939) and Jakobson et al (1952), i.e. the notion that all phonological structures must be established from phonetic evidence - in other words, they must be 'natural' in the sense of §1.5. Further, as this phonetic evidence is also to some extent an abstraction from the continuous stream of speech-sound, this structure should also be defensible in terms of the evidence from the phonetic signal.

Using this type of argument, Griffen maintains that there is no phonetic evidence in favour of "a segmental approach to phonological organization" (1975:203), i.e. in favour of the traditional models of phonological structure in which the notion of the segment plays a role. Such a notion is inherent to all the theories I have surveyed so far, but according to Griffen cannot be defended in terms of acoustic or physiological phonetics. On the basis of this, Griffen proposes an alternative model - the hierarchical model - which, he claims, is consistent with the findings of Mermelstein (1973) and Perkell (1969) in physiological phonetics and with the findings of Öhman (1966, 1967) in acoustic phonetics (1975:204).

The fundamental principles of the hierarchical model, based on these 'dynamic' models of phonetics, are that the segment is abandoned as a phonological unit, and that consonants are not entities in themselves, but are viewed as constraints on vowels. Thus, a stretch of sounds is seen as a constant vocalic pattern, which moves "from one vowel approximation to the next, interrupted only by constraints on vowels themselves". A syllable, then, is a member of this vocalic pattern, and is characterised by a vowel approximation. Thus the transition from one syllable to the next involves a relatively slow transition from, say, the acoustic formant patterns characterising the first vowel approximation to the patterns characterising the next. On the other hand, comparatively rapid transitions are viewed as ob-
structions realised as consonants and glides on the vocalic pattern. It is claimed that the vocalic pattern is traceable from syllable to syllable, and it is in this sense that the consonants can be viewed as interruptions of the constant pattern:

During the obstruction, the physiological vocalic variables may be slightly constrained, but they continue in the vocalic pattern, and acoustically the transition from syllable to syllable can be interpolated mathematically.

Griffen (1975:207) distinguishes three degrees of obstruction - total obstruction (1st degree - closure), partial obstruction (2nd degree - frication), and minor obstruction (3rd degree - sonorants); however, these do not necessarily all occur as obstructions in a particular language.

In addition to the various phonological entities mentioned above - the vocalic pattern, the syllable, and the obstructions - there exist in this non-segmental model a series of 'prosodies'. Prosodies on the vocalic pattern "include the notion of intonation..., and a syllable prosody "is a realisation of a particular quality for the duration of a syllable", such as tone, tunes, pitch, and stress (1975:208). Notice, then, that oppositions among vowels are viewed as syllable prosodies - a syllable, it will be recalled, being a member of the vocalic pattern. In processes such as umlauting, Griffen claims, the prosodies of one syllable can affect the prosodies of some adjoining syllable. Thus, the change of OE i-umlaut discussed earlier would, presumably, be viewed as being brought about by the influence of the syllabic prosodies of one syllable (prosodies of, say, height and frontness) on the syllabic prosodies of the preceding syllable.

However, "the most intricate set of prosodies", and the ones with which I am here largely concerned, are the obstruction prosodies. These prosodies can include 'tension', 'aspiration' (the inverse of voice, which is an inherent quality of the vocalic pattern), 'nasality', etc. The prosodies are associated with the obstruction, and may extend over part or all of the syllable (Griffen 1975:209).
These various patterns, prosodies, etc., give the following hierarchical model of phonological structure (1975:215):

(3.37)

<table>
<thead>
<tr>
<th>Obstruction Prosody</th>
<th>Obstruction Oppositions ('Consonantal' Oppositions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obstruction</td>
<td></td>
</tr>
<tr>
<td>Syllable prosody</td>
<td>Vocalic Oppositions</td>
</tr>
<tr>
<td>Syllable / Transition, Restriction</td>
<td></td>
</tr>
<tr>
<td>Vocalic Pattern Prosody</td>
<td></td>
</tr>
<tr>
<td>Vocalic Pattern</td>
<td></td>
</tr>
</tbody>
</table>

In this model, the oppositions in the higher levels are superimposed upon those in the lower levels. The structure is divided into three general divisions. The vocalic pattern division provides the basis for the representation of the pertinent level (phonetic or phonological) in the abstraction of the speech event. The syllabic division serves to organize the vocalic pattern into sequential order and forms a basis for the obstruction division. The obstruction division constrains the vocalic pattern in accordance with the sequential order of the syllabic division.

After this brief sketch of the general principles of the hierarchical model, we are now in a position to consider the way in which Griffen applies this model to a particular language, Modern Welsh. Specifically, he is concerned with the consonant sub-system of Welsh, and how it operates with respect to the various processes of initial mutation, i.e. processes in which the initial consonant of a word undergoes a phonological change in particular grammatical environments (see chapter 10 below for further discussion). I want now to give some idea of how the characterisations of the various degrees of obstruction and the obstruction prosodies interact. Griffen (1975: 166) gives the following as the consonant sub-system of Welsh, at this stage in traditional phonemic notation (notice that /s/ does not appear, as it does not enter into the phonological mutation processes):
(3.38) 1  2  3  4  2  3
v b p f m ^h (m)
§ d t o n ^h (n).
- g k x o ^h (n)
1 + (4)
r r (6)

(where the representations in brackets are those which I shall use below).

It is appropriate at this stage to consider the motivation for the presentation in (3.38) - i.e. the order voiced fricative, voiced stop, voiceless stop, voiceless fricative. Griffen claims that the opposition of 'aspiration' is the basis of the phonological relationships of the consonant sub-system of Welsh. Specifically:

The synchronic phonological relationships between the columns are the following: Column 2 and column 1 are related through soft mutation ...; column 3 and column 2 are related through soft mutation; column 3 and column 4 are related through spirant mutation ...; the two columns 2 and the two columns 3 are related through nasal mutation.

Thus, for example, /b/ + /v/, /4/ + /l/, and /p/ + /b/ by soft mutation; /p/ + /f/ by spirant mutation; and /b/ + /m/ and /p/ + /m/ by nasal mutation; hence the assignment of the voiced and voiceless nasals to columns 2 and 3. Discussion of these processes can be found in chapter 10.

Griffen argues that the relationship holding between columns 1 - 4 is a gradual opposition of 'aspiration', and that this opposition is the basis of the consonant sub-system of Welsh. This opposition he views as a prosody - that is to say, it is superimposed on the obstruction. Thus column 1 represents the weakest degree of the aspiration prosody, and column 4 the strongest. In the representations of (3.39), column 2 is taken to be basic, and each degree of the aspiration prosody is represented by /h/, and each degree weaker than the basic level as /4/. Nasality is represented by /n/, to give (3.39) (from Griffen 1975:181):
Notice that the representation /g^4/ is not realised in (3.38) - Griffen views it as a phonological 'place-filler' for zero. I return to this matter in chapter 10.

The gradual opposition which Griffen sets up has, he claims, justification in phonetic evidence. As a result of an experiment conducted with Welsh informants, he establishes that there are both acoustic and physiological correlates of the four categories of obstruction in (3.38) and (3.39). The acoustic correlate involves the high-to-low frequency ratio of sound energy associated with the obstruction - as we go from left to right, i.e. from the least to the most aspirated, this ratio increases. The 'voiced fricatives' in the first column, then, have the lowest high-to-low frequency ratio, and the 'voiceless fricatives' in the fourth column the highest. The physiological correlate (taken from Perkell 1969: 36-37) is the width of the orifice of the larynx before consonant release. The width increases as we go from left to right - for the 'voiced fricatives' it is smallest, and for the 'voiceless fricatives' largest.

One further important aspect of the aspiration prosody should be noted - the fact that the members of the opposition split into two groups, according to whether or not the prosody completely inhibits voicing. Thus, the weakest two degrees of the aspiration prosody do not inhibit voicing of 'stops' and 'fricatives', while the strongest do.

We can now examine more formally the relationship between the obstructions and the obstruction prosodies in Welsh. The primary obstructions are members of a gradual opposition of position of articulation (cf. Ladefoged 1971). The members are labial, dental, and
velar, and are represented by Griffen as /b/, /d/, /g/. (Notice, however, that these are not phonemic symbols, but are merely meant to symbolise the obstructions. I shall therefore, in order to avoid any confusion, use a different notation to represent these obstructions, viz. {b}, {d}, {g}.) The primary obstructions are the only ones which are realised as a 1st degree obstruction (i.e. as closure). The secondary obstructions are not defined by "point of articulation" alone, as are the primary obstructions, but also by articulatory configuration (1975:223). These are the lateral {t} and trill {r}, and are not realised as 1st degree obstructions, i.e. there are no lateral or trill obstructions with closure. There is only one member of the class of tertiary obstructions - the 'apico-alveolar slit fricative' {s}, which differs from the other obstructions in entering into only one relationship with one obstruction prosody, as we shall see below. Notice again that, in traditional terms, the phoneme /s/ differs from the other voiceless fricatives, in that it does not enter into the same phonological relationships. It does not, for example, take part in the various mutation rules. The obstruction oppositions of Welsh, then, can be represented as (3.40):

(3.40) \{b d g\} \{t r\} \{s\}

(Primary) (Secondary) (Tertiary)

Superimposed upon these obstructions are the obstruction prosodies - the aspiration prosody, and the nasality prosody. Unlike the aspiration prosody, the nasality prosody is privative in Welsh. The nasality prosody is represented formally as (n), and the aspiration prosody as (q 0 h hh). (I again, for clarity, introduce a different bracketing for the identification of prosodies.) Thus Griffen introduces the symbol (0) to represent the second degree of aspiration. He also notes (1975:225) that the use of these particular symbols is a notational convenience: "I could just as easily represent the opposition members as /1h/, /2h/, /3h/, and /4h/" - a notation already familiar from the non-binary feature systems of chapter 2. Thus the full system of prosodic and obstruction oppositions in Welsh is shown as (3.41) (from 1975:231):
These two sets of oppositions "enter into relationships to produce the various 'sounds' of Welsh, each consisting of one member of the obstruction opposition and one member of either or both prosodic oppositions". However, there are restrictions on what may combine with what, restrictions which Griffen represents as (3.42):

\[
\begin{array}{cccc}
\text{(n)} & \text{(Primary \ obstructions)} & \text{(Secondary \ obstructions)} & \text{(Tertiary \ obstructions)} \\
\{b, d, g\} & \{t, \#\} & \{s\} & \\
\end{array}
\]

Thus, primary obstructions may enter into relationships with any of the aspiration prosodies, either alone (corresponding, in the dental series, to traditional /ð d t ð/), or in the case of the 2nd and 3rd degrees of aspiration also with the nasality prosody (e.g. /n ð/). Secondary obstructions may enter into relationships with the 1st and 2nd degrees of the aspiration prosody (/l 4 ð ¥/), and the tertiary obstructions only with the 2nd degree of aspiration (/s/). Thus (Griffen 1975:230):

The nasal member of the opposition of nasality may constrain... the second or third member of the opposition of aspiration and (simultaneously)... any primary obstruction. The first and second member of the opposition of aspiration may constrain any secondary obstruction. The second member of the opposition of aspiration must constrain the tertiary obstruction.

The prosodies, then, are viewed as constraints on the obstruction oppositions.

I have gone into Griffen's theory in some detail because it diverges in some interesting respects from the other notational systems.
examined above. Notice that the hierarchical model differs from the prosodic and autosegmental models in its explicit rejection of the segment as a phonological unit, while the other models maintained a unit of segment size as the basic phonetic unit. Clearly, this non-segmental aspect is the most important respect in which the hierarchical model differs from any of the other theories discussed in chapters 2 and 3. However, it also differs in other ways. The obstructions of the hierarchical model, unlike the segments of feature theory, appear not to be minimally componential, but to have, as can be seen from (3.42), various kinds of internal structure. Notably, the privative nature of the nasality opposition means that obstructions may differ in whether or not the nasality prosody is present. Further, while the feature-values of the sPE theory are not divided into subsets, as we saw in chapter 2, the obstructions are characterised by different groups of oppositions, as in (3.42). Thus, the structure of the phonological units of the hierarchical model allows a greater variety of structural possibilities than is available within the minimally componential distinctive feature theories.

However, there are various aspects of the hierarchical model which raise questions. What, for example, is the motivation for the particular constraints on the relationships between the obstruction oppositions and the prosodic oppositions in (3.42)? That is, why can secondary obstructions in Welsh only enter into relationships with the first and second degrees of aspiration, and not at all with the nasality prosody? If this were a phenomenon peculiar to Welsh, we might not expect there to be a way of characterising it in the notation. However, these restrictions will be appropriate for nearly all languages (indeed, most languages would be even more strongly constrained, allowing secondary obstructions to enter into relationships only with one of the degrees of the aspiration prosody), and it seems reasonable to expect this to be reflected in the notation. There is no way of predicting whether any hypothetical constraint holding between elements of the obstruction oppositions and the prosodic oppositions is more or less natural than any other. We might level a similar criticism against the postulation of the gradual opposition of...
the aspiration prosody in Griffen's system. Why should the (Ø) degree of opposition be able to enter into more phonological relationships than any other?

We shall see in later chapters that some of the concepts of the hierarchical model are similar to the proposals of dependency phonology, but, I shall submit, an interpretation within the formalism of dependency theory gives a more satisfactory account of these concepts, in particular with respect to the characterisation of the aspiration prosody. In chapter 10, I shall consider Griffen's account of the various mutation phenomena in Welsh, and shall also offer a dependency interpretation of these processes.

3.5 Metrical phonology

Finally in this chapter, I want to consider a model of phonological representation in which, again, a greater degree of structure is apparent than in the distinctive feature system of SPE, but in which the greater degree of structure is to be found not within the segment, but within phonological sequences. This is the theory of metrical phonology, first developed in Liberman and Prince (1977); see also Kiparsky (1979), McCarthy (1979), and Selkirk (ms).

Liberman and Prince (1977:249) state that the theory of metrical phonology:

1. employs two basic ideas about the representation of traditional prosodic concepts: first, we represent the notion relative prominence in terms of a relation defined on constituent structure; and second, we represent certain aspects of the notion linguistic rhythm in terms of the alignment of linguistic material with a 'metrical grid'.

Thus, we may characterise the theory as one in which a structure (other than a simple linear sequence) is imposed on a string of segments.

As can be seen from the quotation above, relative prominence is defined with respect to the constituents of an utterance. Thus, in a syntactic tree, the nodes are marked w ('weak') and s ('strong').
A compound such as English <stress shift> (Liberman and Prince 1977: 256), then, in which the first element is more stressed than the second, and therefore strong, is represented as (3.43):

(3.43)

\[ \text{stress shift} \]

It should be noted that because 'relative prominence' is indeed a relational notion (in Liberman and Prince's terms "a relation defined on sister nodes"), the labels s and w are only meaningful with respect to each other; i.e. a node can only be strong in comparison with a sister node which is (relatively) weaker.

Similar structures are apparent within the word. Thus, Liberman and Prince (1977:264) note that "it accords quite directly with the intuition behind metrical comparison to regard the stressed syllable as strong, its unstressed compeers as weak". The following trees result:

(3.44)

\[ \text{modest} \]

\[ \text{balloon} \]

\[ \text{gymnast} \]

while in a three-syllable word we find:

(3.45)

\[ \text{pamela} \]

Notice that it is one of the principles of metrical phonology that all branching is binary. The relative prominence relation, then, holds only between the two sisters of a binary branching structure.

Liberman and Prince observe that only [+stress] vowels can be s, so that all [-stress] vowels are w, a constraint which they formulate as:
(3.46) \[ *s \]

\[ V \]

[-stress]

The other possible branching structures for <Pamela> are eliminated by this constraint.

Perhaps the most important aspect of the Liberman and Prince treatment of stress, then, is that "relative prominence is defined between phonological constituents, rather than on individual segments" (1977:333), while in the SPE model individual vowels are assigned a particular value for the (scalar) feature [stress], thus implying that, say, the value [2 stress] is absolute. In the SPE interpretation, it appears that the phonetic value of a vowel bearing the specification [2 stress] can be determined independently of the context in which the vowel appears. I return to this matter in chapter 7.

I turn now to another aspect of metrical phonology, the internal structure of the syllable. Kiparsky (1979:432) argues that syllabification is governed by a universal rule which assigns a metrical structure to strings of segments, and which may be augmented by language-particular rules. The universal core rule requires an optimal matching of the syllabic template [(3.47a)] to the well-known sonority hierarchy [(3.47b)]:

(3.47) a.

b. Sonority Hierarchy: stops, fricatives, nasals, l, r, w, y, u, l, o, e, a

(where the label \( \sigma \) denotes a syllable). Within any "pair of adjacent
segments in a σ, the one marked s is the more sonorous in terms of the sonority hierarchy. (For a discussion of such hierarchies, see §7.2). Thus, <pad> has the following tree:

\[\begin{array}{c}
\sigma \\
&s \\
&w & s & w \\
&l & l & l \\
&p & a & d
\end{array}\]

Notice the higher branching structure in (3.48). McCarthy (1979:454) argues that within any syllabic tree the "rhyme" (i.e. the syllable nucleus plus any following vowel or consonant) forms a constituent within the tree, and cites a number of processes in which the rhyme is affected. Thus, he argues, all syllables have structures like those in (3.49), in which the rhyme is circled:

\[\begin{array}{c}
\alpha \\
&s \\
&w & s & w \circ \\
&l & l & l \\
&C & V & V
\end{array}\]

\[\begin{array}{c}
\alpha \\
&s \\
&w & s & w \circ \\
&l & l & l \\
&C & V & C
\end{array}\]

\[\begin{array}{c}
\alpha \\
&s \circ \\
&w & l \\
&l & C \\
&V
\end{array}\]

(In (3.49a) long vowels are treated as bimoric; for a discussion of this in more general terms, see §7.4.1 and 8.4.)

Finally, I want to consider a somewhat revised version of Liberman and Prince's theory of metrical phonology, that of Selkirk (ms). Selkirk observes:

[the conception of suprasegmental representation found in Liberman and Prince] is too impoverished and . . . it is necessary to posit prosodic categories, i.e. specific differentiated sub-units of prosodic structure, which 'label' the nodes of the tree. These prosodic categories are the syllable, the foot, the prosodic word, the phonological phrase, the intonational phrase and the utterance.

She is concerned primarily with showing that there is a difference between phonological structure (as defined by metrical trees) and
syntactic structure; however, I shall not consider this matter here, but will confine my discussion to the "prosodic units at the level of the syntactic word or lower", i.e. the syllable (σ), the foot (ζ), and the prosodic word (ω).

As in Kiparsky's presentation, the syllabic tree is a binary branching structure consisting of an onset and a rhyme, as in (3.50), the syllabic tree for English <flounce>:

(3.50)

```
  σ
    \   /
     f a w n s
    \     /
      on\  peak coda
      \    /
       rhyme
       \  /
        syllable
```

while in terms of a s/w labelling, we have:

(3.51)

```
  σ
    \     /
     s w s w s w
    \     /
      s w s w s w
    \     /
      s w s w s w
    \     /
      f l a w n s
```

where the principles found in (3.47) above are retained; more sonorous elements are s in comparison with their sisters, which are assigned "ω (= 'subordinate' status)".

Selkirk adduces various pieces of evidence which support the notion that the syllable is a highly structured unit in the prosodic hierarchy, which I shall not investigate here (see however chapter 7). Syllables are organised into the next highest prosodic unit, the foot, the definition of which may be language-specific. In English, the following are possibilities:
(3.52) The basic feet:

(i) \[ \begin{array}{c}
\Sigma \\
\sigma \\
C_0 \\
V \\
G
\end{array} \]

e.g. probate

(ii) \[ \begin{array}{c}
\Sigma \\
\sigma \\
C_0 \\
V \\
C_1
\end{array} \]

e.g. gymnast

(iii) \[ \begin{array}{c}
\Sigma \\
\sigma_s \\
\sigma_w \\
C_0 \\
V \\
C_0
\end{array} \]

e.g. modest

(VG = tense vowel or diphthong)

The super foot

(iv) \[ \begin{array}{c}
\Sigma' \\
\Sigma_s \\
\sigma_w \\
C_0 \\
V \\
C_0
\end{array} \]

e.g. sofa

\[ \begin{array}{c}
Pamela \\
\Sigma' \\
\Sigma_s \\
\sigma_w \\
\sigma_w \\
\sigma_w \\
\sigma_w
\end{array} \]

Such templates, like syllabic templates, "function as well-formedness conditions on underlying representations". One of the advantages which Selkirk claims for her account over that of Liberman and Prince is in the treatment of the pair <gymnast>/<modest>, which
in the Liberman and Prince treatment have the same metrical tree (cf. (3.44)). Liberman and Prince have to distinguish the trees by marking the vowels with the feature [±stress], as in (3.53):

(3.53) 

Selkirk argues that this feature can be eliminated, as the difference between the two items can be associated with their different status with respect to the foot; the second syllable of <gymnast> is in itself a foot, and is therefore 'stressed', while the second syllable of <modest> is weak and is not a foot, and is therefore 'unstressed'. Notice further that the first syllable of <modest> is stressed, because it is the strong element of a bisyllabic foot. (It is not, however, clear whether there is independent evidence for the difference in "foothood" between the two forms in (3.53).)

Selkirk claims that there are phonological processes whose domain is the foot. For example, flapping processes (e.g. /t/ → [ç]) occur only within the foot. Thus, intervocalic /t/ in <total> can become a flap, as the two syllables form a single foot. Finally, the feet are joined in a right branching structure, to give the prosodic word. s and w are assigned on the following principle, taken from Liberman and Prince:

(3.54) The Prosodic Word: Prominence

Given a pair of sister nodes [N₁ N₂], N₂ is s iff it branches.

Thus the internal structure of <irrespective> is:
In this section I have presented in broad outline those aspects of metrical phonology which are most important for the arguments that follow. It will be seen that this theory of phonological notation differs from the others considered in this chapter, in that it retains the notion of the segment. Rather, the added degree of structure which is apparent in the model comes in the hierarchisation of sequences of segments. Although my main concern in what follows will be with the internal structure of segments, rather than of sequences, various aspects of the metrical theory will be of relevance. In chapter 4, for example, I return to the notion of relative prominence, and will suggest that it can be better expressed formally than by the use of labelled constituency trees. In chapter 7, too, I consider again the internal structure of the syllable, with particular reference to the sonority hierarchy and its characterisation, and also the characterisation of stress.
Chapter 4

Notational Systems 4: The Dependency Model

In this chapter I give an account of the principles underlying the notational system which will be developed throughout the rest of this thesis - the notational system of dependency phonology. In §4.1 I show how the theory of dependency can be used in the characterisation of structures larger than the segment - e.g. syllables and words - while in §§4.2 and 4.3 I apply the theory to the internal structure of the segment, and develop a set of vowel 'components' which can enter into various dependency relationships.

4.1 Dependency between segments

In the SPE notational system, as noted in chapter 2, words consist of linearly ordered strings of segments (which in turn are characterised by unordered sets of feature-values). There is no structure involved in sequences of segments, other than this linear ordering, as shown in (4.1):

(4.1) A B C D E F ...

In some of the models considered in chapter 3, it was seen that the state of affairs characterised in (4.1) did not hold. In prosodic analysis, for example, we saw that certain phonological units - the prosodies - had as their domain structures of other sequentially ordered units - the phonematic units. A similar relationship was found in the autosegmental model, a relationship which we might represent as (4.2):
where the prosodies (or autosegments) \( x \) and \( y \) are shown to have respectively the strings \( A-D \) and \( A-E \) as their 'scope'. In the model of metrical phonology, we saw that segments were organised into higher phonological units, such as the syllable and the foot.

In this section, I want to show that an interpretation of phonological structure is possible using the notion of relationships of dependency, an interpretation which is rather different from any of those discussed so far. Such dependency relations have been postulated in syntax to represent head-modifier relationships in both endo- and exocentric constructions (see, for example, Hays 1964 and Robinson 1970), and the notational system of the localist case grammar of Anderson (1971a, 1971b, 1971c) involves dependency relations holding between nodes in trees. In dependency grammars, dependency trees are assigned to syntactic sequences instead of the phrase structure trees of constituency grammars such as that of Chomsky (1965). (4.3), then, from Anderson (1971a:73), is a dependency tree representing the sentence \(<\text{John was beaten by Bill}>\):

\[
\begin{array}{c}
\text{V} \\
\text{nom} \\
N \\
g \text{John} \\
\text{was beaten} \\
\text{by} \\
\text{Bill}
\end{array}
\]

In [(4.3)] the categories (which are all lexical) are hierarchized in terms of dependency rather than constituency. V 'governs' nom and erg [i.e. nominative and ergative; two of the case elements of the theory of case grammar] (they are dependent on V [verb]); they in turn govern their respective Ns.
The dependency relations in (4.3), then, are used to express the hierarchical relationships of the theory. Thus (4.3) is a dependency tree, consisting of a number of nodes, each of which is labelled (nom, V, etc.). The nodes are connected to each other by branches. The verb, considered as the head of the whole construction in these dependency grammars, is the ultimate governor, and hence the root, of the structure, and all other categories are subordinate to the governor. In turn, the case labels (nominative and ergative) are the governors of the category label N. Two types of relationship are present in the tree; the nonsymmetrical relationship of dependency, which is represented on the vertical dimension (where two nodes are joined by a branch, the governing element is placed higher than the element which it governs), and precedence, which is represented on the horizontal dimension (i.e. normal left-to-right order). We may represent the dependency relationship as \( a \rightarrow b \) (i.e. \( a \) governs \( b \)), or, equivalently, as \( b \rightarrow a \), and the relationship of (strict) precedence as \( a < b \) (i.e. \( a \) precedes \( b \)), or as \( b > a \). This concept of representation allows Anderson and Jones (1974a:14) to characterise the various combinations of these relationships as (4.4):

(4.4) a. \( a < b , a \rightarrow b \)  

\[ a \]
\[ \rightarrow \]
\[ b \]

b. \( a < b , a \rightarrow b \)  

\[ b \]
\[ \rightarrow \]
\[ a \]

c. \( a > b , a \rightarrow b \)  

\[ a \]
\[ \rightarrow \]
\[ b \]

d. \( a > b , a \rightarrow b \)  

\[ b \]
\[ \rightarrow \]
\[ a \]

Thus, in (4.3) we have the relationships in (4.5):
(4.5) nom < N < V < erg < N ; N ≠ nom ≠ V ≠ erg ≠ N

It is claimed that these notions may be appropriate for the characterisation of phonological relationships to the extent that we can motivate unique governors for particular phonological structures. Anderson and Jones suggest that just such a characterisation is appropriate for the syllable. The syllabic element may be interpreted as the head and therefore the governor of the syllable - Anderson and Jones (1977:117) note that:

the syllabic element is that element in a syllable which is obligatory and characteristic. By characteristic we intend something like 'serving to characterise a syllable': a 'syllable' without a syllabic element is not a syllable.

Notice that this notion is also used in establishing heads in syntax (cf. Robinson 1970, Anderson forthcoming). The non-syllabic elements, then, are dependent on the syllabic. Thus, the following graph is appropriate for Dutch <put> /pɔt/ 'well':

(4.6)

\[ \begin{array}{ccc}
& \phi & \\
\phi & & t \\
\end{array} \]

Notice that (4.6), in which the symbols are located immediately below the appropriate nodes (the discontinuous lines indicating the node assignments of the categories) is equivalent to the tree in (4.7):

(4.7)

\[ \begin{array}{ccc}
& \phi & \\
\phi & & t \\
\end{array} \]

in which the nodes are labelled with elements corresponding to the segments involved. However, representations like (4.7) are only appropriate if segments have no further internal structure involving the dependency relationship; we shall see below that this extra degree of structure is in fact necessary, and so I shall use representations like (4.6) rather than (4.7).
In (4.6) and (4.7), then, the most prominent element in the syllable, /ə/, governs both the non-syllabics, /p/ and /t/. In a bisyllabic word such as Dutch <bezem> /beːzəm/ 'broom', the two-syllabics are again selected as governors of their respective syllables, to give (4.8):

(4.8)

It will be seen that in (4.8) the intervocalic /z/ is dependent on the syllabics of both syllables, i.e. /e/ /a/. Here and elsewhere, I adopt the 'overlap' theory of the syllable (see Anderson and Jones 1974a:§1, Anderson 1975, 1977, Jones 1973, 1976, 1977); that is, the theory that intervocalic consonants, under certain conditions, are assigned simultaneously to both syllables. In (4.8), then, /z/ forms the coda of the first syllable, while simultaneously being the onset of the second syllable. I return to this matter in §7.1.1.

However, (4.8) is a tree without a unique centre, i.e. it is multi-rooted, such that there is no single ultimate governor of the whole word. Anderson and Jones (1974a:18) suggest that it is in fact appropriate for all words to have a unique governor - the stressed element in the word is the governor. Thus, while the syllabic elements govern the non-syllabics, there is a further dependency relationship, such that the stressed syllabic governs all the other syllabics, as in (4.9), or equivalently, (4.10) and (4.11):

(4.9)
In (4.10), the nodes in the tree are labelled, while in (4.11) the governing /e:/ is said to be of a dependency degree of 0, while the non-stressed syllabic is of a dependency degree of 1, and the non-syllabics of a dependency degree of 2. The calibration in this way of the nodes in (4.11) shows that the first, third, and fifth segments all have the same degree of dependency. By convention, however, this is generally indicated only by the fact that they are on the same level on the vertical dimension, as in (4.9) and (4.10).

This informal sketch of dependency theory shows how it might be applied to the phonological structure of words and syllables. As yet, of course, I have not shown that there is any value for phonology in being able to establish structures such as (4.9)-(4.11), apart from the fact that they seem to provide an intuitively satisfying and reasonably well-motivated analogue of the relations of prominence holding between the various segments. Dependency theory, then, correctly characterises the notion that the syllabic is the obligatory, characteristic element (i.e. the 'head') of the syllable, and similarly, that the stressed syllabic is the 'head' of the (non-grammatical) word - all such words must have a single stressed syllabic.

In chapter 7 I shall show that these concepts are indeed appropriate for phonology. For a more formal account of the theory of dependency phonology, the reader is referred to Anderson and Jones
4.2 Dependency within the segment

It is also possible to postulate the existence of dependency relationships within the segment. That is to say, in a componential phonology, the components may occur, not as an unordered set as in the distinctive feature theories of chapter 2, but as a set whose members enter into various asymmetrical relationships with each other, relationships which can again be modelled in terms of dependency. This notion of componentiality, then, requires that we first of all establish the nature of the components, and secondly, that we motivate the claim that certain components should be able to govern others.

Before attempting to do this, however, I shall consider (following Anderson and Jones 1974a: 2) the types of structure which can be represented if we add the possibility of dependency within the segment. In (4.4) it was seen that four possible structures could be generated by using two variables, together with the relationships of dependency and strict precedence. If, now, we introduce dependency within the segment, the appropriate graph for the relationship \( a \sqsupset b \), when \( a \) and \( b \) are components of a single segment, is (4.12):

\[
\begin{array}{c}
a \\
\xrightarrow{b}
\end{array}
\]

In (4.12), \( a \) and \( b \) are coincident in precedence, i.e. \( a \leq b \) and \( b \leq a \) (or, alternatively, neither \( a < b \) nor \( b < a \) holds). This relationship may be represented as \( a = b \). (4.13) shows the formalised representation of coincidence:

\[
\begin{array}{c}
a = b, \ a \sqsupset b \\
\xrightarrow{a}
\end{array}
\]
b. \( a = b \), \( a \supset b \)

In (4.13a) \( b \) is said to be subjoined to \( a \) (and vice versa in (4.13b)), while in (4.4a) and (4.4c) \( b \) is adjoined to \( a \) (and vice versa in (4.4b) and (4.4d)). Thus the dependency relationship under conditions of coincidence is a subjunction relationship; under conditions of difference in precedence it is an adjunction relationship.

The subjunction relationship has also been used in syntax. Anderson (1971c) argues that the two sentences in (4.14) share the common abstract structure (4.15), which is also the surface structure of (4.14a):

(4.14) a. John gave me help.
    b. John helped me.

(4.15)

```
(\[ V \]
  \[ erg \]
    \[ abl \]
      \[ N \]
        John
    \[ loc \]
      \[ to \]
        \[ N \]
          gave
        \[ abl \]
          \[ N \]
            me
      \[ loc \]
        \[ to \]
          \[ N \]
            help
```

(where loc and abl are the case nodes locative and ablative). In the derivation of (4.14b) the last \( N \) is subjoined to the case node nom, and nom is subjoined to \( V \), to give a 'complex segment', as in (4.16):
The structure governing <gave help> is a segment which is complex in the sense that it is made up of various syntactic primitives, which stand in dependency relationships to each other. The complex <gave help> is lexicalised to give the word <helped>.

Other possible combinations of the precedence and dependency relationships exist. a and b may be co-dependent (i.e. mutually dependent or mutually governing), that is a \(\preceq b\) and \(b \succeq a\). This relationship may be represented as \(a \equiv b\). If \(a \equiv b\), and a and b are distinct in precedence, we have the two possibilities in (4.17):

\[(4.17)\]

\[\begin{align*}
\text{a. } & a < b, \quad a \equiv b & a & \hspace{1em} \rightarrow b \\
\text{b. } & a > b, \quad a \equiv b & b & \hspace{1em} \rightarrow a
\end{align*}\]

Finally, a and b may be mutually dependent and coincident. This state of affairs is shown in (4.18):

\[(4.18)\]

\[a = b, \quad a \equiv b \quad \text{a:b or b:a}\]

In (4.18), it makes no difference which of the two graphic representations is employed - there is, of course, no ordering relationship between a and b, because of the condition \(a = b\). We shall see below, however, that the relationship of mutual dependency is only required in systems in which the relationships of unilateral dependency (i.e. \(a \succeq b\) and \(b \preceq a\)) are also required. In other cases, a relationship of simple combination is sufficient, as in (4.19):
where no dependency relations hold between a and b.

The above represent the possible combinations of a and b. I want now to confine my attention to representations in which a = b. There are four possibilities:

\[
(4.20) \quad a \quad a:b \quad b \quad a:b \\
\quad b \quad a
\]

However, given the definition of the relationship of simple combination, it appears that the last representation in (4.20) cannot occur in a system with any of the first three. That is, all of a \(\nRightarrow\) b, b \(\nRightarrow\) a, and a \(\nLeftarrow\) b are instantiations of a:b, and are therefore not distinguishable from it; rather, they are all in a 'hyponomous' relationship to the 'superordinate', a relationship which might be represented as (4.21):

\[
(4.21) \quad a:b \\
\quad a \quad a:b \\
\quad b \quad a
\]

Thus, whenever a contrast is required between two or three items containing both a and b, representations involving dependency relationships rather than simple combination are required.

Suppose now that we consider phonological segments to be made up of various components, among which are a and b, which may contract dependency relationships with each other. Further, we have three segments which differ only in the respect shown in (4.20) - that is, they all contain the components a and b, but the dependency relationships holding between a and b are different. In the first case, a \(\nRightarrow\) b, in the second, a \(\nLeftarrow\) b, and in the third, a \(\nRightarrow\) b. (I ignore the representation a:b, for the reasons outlined above.) This characterisation
allows an immediate interpretation of the notion of 'gradual opposition'. As we move from the first to the third segment, \(a\) becomes less prominent (going from governing alone to mutually dependent to dependent alone), while, conversely, \(b\) becomes more prominent. The representations, then, become gradually more '\(b\)-like' and less '\(a\)-like'.

We may introduce another structural variable, however. Let us assume that components are not entities that are omnipresent; rather, they may be present or absent in the representation of a segment. In addition to the different dependency relationships which can hold between \(a\) and \(b\), then, we can suggest that there are two further segments which differ from those in (4.20) in lacking either \(a\) or \(b\). The introduction of this possibility gives the set in (4.22):

\[
(4.22)\quad a \quad a:b \quad b \quad b
\]

\[
\quad b \quad a
\]

The concept of a scalar relationship between the representations is even clearer in (4.22) than in (4.20). At one end of the scale, segments are most \(a\)-like and least \(b\)-like (in that they contain \(a\) alone and lack \(b\)). As we move from left to right \(a\) becomes gradually 'diluted' and less preponderant, and \(b\) becomes more 'concentrated' and more preponderant, until at the right hand extreme segments are most \(b\)-like and least \(a\)-like (having \(b\) alone and lacking \(a\)). The adoption of these representations allows the natural expression of Trubetzkoy's gradual oppositions.

However, in chapter 2 we saw that scalar features, which were also appropriate for the characterisation of scales such as these, could not handle the classificatory properties of individual segments which were members of a particular scale. Such feature systems were not able to distinguish appropriately subsets of the set of values constituting a scalar feature. For a scale such as that characterised by (4.22), the following representations might be appropriate for a scalar feature system:
A choice would have to be made between (4.23a) and (4.23b). While the representations in (4.23) would not permit characterisation of the classificatory properties of the scale in question, the dependency display in (4.22) can. The subset of the full set constituted by the first value is the set which contains a alone, i.e. the class \( \{ a \} \), or \( \{ a \rightarrow 0 \} \), where 0 is the identity element; the subset constituted by the first two values contains all segments in which a is not dependent (whether mutually or unilaterally), i.e. \( \{ 0 \leftrightarrow a \} \); the subset constituted by the first three values contains all segments in which a is governing (again including the case of mutual dependence), i.e. \( \{ a \uparrow \} \); the subset constituted by the first four values contains all segments containing a, i.e. \( \{ a \} \); the subset constituted by the second, third, and fourth values contains all segments which contain both a and b, i.e. \( \{ a.b \} \).

I turn now to the application of a system like this to a particular area of phonology - the characterisation of the vowel space, which I have already examined with respect to various of the phonological models in the last two chapters. As the characterisation of the vowel space in dependency terms develops, it will be seen that the dependency model has various other properties besides those just discussed, properties which, it was claimed in chapter 1, should be present in a phonological notation, but which were not to be found in all of the models in chapters 2 and 3.

4.3 Vowel components

In §3.1, I examined the theory of natural phonology, in which the vowel space was characterised by a set of properties; palatality, labiality, and sonority. I want now to explore the consequences for the characterisation of vowels of treating these three properties as components of the type discussed in the previous section. It will be recalled that the natural phonology proposals had several drawbacks.
Although the model appeared to assume that the individual properties were not omnipresent in the characterisation of a segment (so that, for example, [α] lacked both palatality and labiality), the notational system associated with natural phonology in no way reflected this claim. Further, the distinction which was made between 'pure' and 'mixed' vowels could not be represented, and as a result, the possibility of the model defining relative complexity between vowels was also absent. All of these problems, it will be claimed here, can be overcome by adopting the dependency model, while retaining the three cardinal vowel properties of natural phonology. In the meantime, I shall assume that these three properties, with their definitions, are appropriate. In chapter 8, however, I shall examine in detail the case for proposing these particular properties, and shall offer a more refined account of the phonetic correlates which can be associated with each of the vowel properties. In this section, then, the following components will be used:

\[(4.24) \text{[i]} ('\text{palatality}')
\]
\[\text{[u]} ('\text{labiality}')
\]
\[\text{[a]} ('\text{sonority}')
\]

Dependency components as such (as opposed to dependency components when used to characterise classes of segments) are enclosed between verticals, as in (4.24), and are distinguished in this way from other types of phonological representations.

Using these dependency components, we are now in a position to offer a characterisation of the vowel triangle of (3.3). This vowel triangle represents the simplest possible phonemic vowel system found in language. Crothers (1978:109), in a survey of the vowel systems of a large set of languages of the world, notes that there are 23 vowel systems which contain only three phonemic vowels, and all are of the same type, in that the "three vowels stand in the same relative relationship, and occupy the same regions of the vowel space". Although the phonetic quality may vary, they all have vowels which might appropriately be given the phonemic representations /i u a/. A system like this might be characterised as (4.25):
A representation within curly brackets, as in (4.25), indicates that the representation characterises a segment (insofar as the vowel space is concerned). \(|i|\), then, is equivalent to \(\{i \Rightarrow 0\}\). Thus, the vowel /i/ in (4.25) is characterised by the presence of the palatality component, and the labiality and sonority components are absent. Similarly, /u/ is characterised as labial, but non-palatal and non-sonorant, and /a/ as sonorant, but non-palatal and non-labial. Thus the notions of natural phonology in this respect are given a very natural interpretation in terms of the notation used in the dependency model, specifically by the adoption of components which may be present or absent, and hence by allowing components to be characterised by the presence of just a single component.

In §4.2, it was seen that components might also be combined in various ways. Let us assume that the vowel components may be combined to characterise segments in the manner shown in (4.26):

\[
(4.26) \{i,u\} \quad \{i,a\} \quad \{u,a\}
\]

In a six vowel system such as (4.27), the representations in (4.26) would characterise /y/, /e/, and /o/ respectively:

\[
(4.27) /\text{y}/ \quad /\text{e}/ \quad /\text{o}/
\]

/y/, represented by \(|i.u|\), is viewed as a vowel having both the palatality and labiality properties, but lacking sonority; /e/ - \(|i.a|\) - as palatal and sonorant, but non-labial; and /o/ - \(|u.a|\) - as labial and sonorant, but non-palatal. A further combination is
possible - the simple combination of all three properties:

\[(4.28) \{i.u.a\}\]

\[(4.28)\] is a vowel which is palatal, labial, and sonorant; i.e. in traditional terms a front, round, mid vowel such as /o/. A seven vowel system incorporating all these simple combinations, then, would be represented as \[(4.29)\]:

\[(4.29) \{|i|\} -\{i.u\} -\{u\}\]

\{|i.a\} -\{|i.u.a\} -\{|u.a\}\]

\{|a|\}

The various lines connecting the representations in \[(4.29)\] show the existence of gradual oppositions. Thus, in the dimension of vowel height, there are gradual oppositions /i/-/e/-/a/, /u/-/o/-/a/, and /y/-/∅/-/a/, while in the dimensions of palatality and labiality, there are the gradual oppositions /l/-/y/-/u/ and /e/-/∅/-/o/. These gradual oppositions are appropriately represented in \[(4.29)\] in the same way as the oppositions involving a and b which were discussed in §4.2. (For ease of illustration, I use a triangular representation in \[(4.27)\] and \[(4.29)\], and below. This is not, of course, to be taken as a claim that /y/, /∅/, etc. are central vowels.) \[(4.29)\], then, captures the relation between chromaticity and sonority which, it was claimed by the natural phonologists, are in an inverse scalar relationship. If we consider the dimension of front vowels, for example, we see that as we move down the scale, the representations become more /a/-like and less /i/-like. The vowel /l/ shows /i/ most preponderant, while for /e/, /i/ is less preponderant by virtue of the presence of /a/, thus reducing the /i/-ness of the segment, and for /a/, /i/ is absent. Similar relationships hold within the other dimensions indicated in \[(4.29)\].

It can also be readily seen that Donegan's distinction between
'pure' and 'mixed' vowels is represented in a formally satisfying way. Pure vowels are those containing only one component, while mixed vowels are those containing two or three. The adoption of a system in which components are not universally present allows these claims to be reflected in a very transparent way, a way which is not available to systems which use features of the type discussed earlier.

In turn, the processes of bleaching and colouring (as defined by Donegan) can be given a more natural interpretation. The bleaching of \[y\] can be shown as (4.30):

\[(4.30)\]
\[
a. \ [y] \rightarrow [i] \quad \{i,u\} \rightarrow \{i\} \\
b. \ [y] \rightarrow [u] \quad \{i,u\} \rightarrow \{u\}
\]

where (4.30a) involves bleaching by delabialisation and (4.30b) bleaching by depalatalisation. The characterisation of bleaching as the loss of a colour is represented in (4.30) as just that - the removal from the representation of one of the basic components. (Notice that in (4.30) I use the representation \{i,u\}, rather than \{i.u\} or \{i \equiv u\}. From now on I use this convention to represent cases of coincidence in which the distinction between simple coincidence and mutual dependency is unimportant.)

Bleaching of \[i\] and \[u\], however, gives a segment - \[\epsilon\] - which contains neither the \[i\] nor the \[u\] component, as shown in (4.31):

\[(4.31)\]
\[
a. \ [i] \rightarrow [\epsilon] \quad \{i\} \rightarrow \{\sim\{i,u\}\} \\
b. \ [u] \rightarrow [\epsilon] \quad \{u\} \rightarrow \{\sim\{i,u\}\}
\]

Colouring, of course, involves the reverse effect - a basic component is added. Thus the colouring of achromatic vowels shows the reverse of (4.31):

\[(4.32)\]
\[
a. \ [\epsilon] \rightarrow [i] \quad \{\sim\{i,u\}\} \rightarrow \{i\} \\
b. \ [\epsilon] \rightarrow [u] \quad \{\sim\{i,u\}\} \rightarrow \{u\}
\]

A more formal and more developed account of the characterisation of back vowels is offered in chapter 8.
It can also be argued that the dependency model appropriately reflects the conditions under which bleaching and colouring are favoured. Bleaching, it will be recalled, favours mixed low vowels over pure high vowels. Thus, the change \([i] \rightarrow [\ddagger]\) is less favoured than \([\phi] \rightarrow [\ddagger]\), which in turn is less favoured than \([a] \rightarrow [\ddagger]\). In §3.1 we saw that the notation of the natural phonology model did not reflect this. In the dependency model, the various changes are:

\[(4.33)\]

a. \([i] \rightarrow [\ddagger]\) \quad \{\{i\}\} \rightarrow \{\sim\{i, u\}\}

b. \([\phi] \rightarrow [\ddagger]\) \quad \{\{i, u, a\}\} \rightarrow \{\{i, a\}\}

c. \([a] \rightarrow [\ddagger]\) \quad \{\{i, a\}\} \rightarrow \{\{a\}\}

(4.33a) is shown to be a poor candidate for a bleaching process, in that the basic causality of any phonological process - i.e. to increase distinctiveness by making the vowels less 'mixed' - is absent. The (maximally distinct) pure vowel \([i]\) becomes something which is negatively specified - lacking all components, it is minimally distinctive. (4.33b) is a better candidate, in that the change increases the distinctiveness of the segment by changing a vowel containing all three components into a vowel containing only two, thus making it less mixed. (4.29c) is the best, in that the change produces a maximally distinct vowel, characterised by the presence of a single component.

Colouring, involving the reverse hierarchy of favourability of application, shows the reverse ordering from that in (4.33). Thus the reverse of (4.29a) is shown to be a highly favoured colouring process, as it creates a maximally distinctive representation from a minimally distinctive one.

Associated with the distinction between pure and mixed vowels is the concept of relative complexity. The relative complexity of, say, /\phi/ compared with /\gamma/, and /\gamma/ compared with /\iota/, is inherent in their representations - /\phi/ requires three components in its specification, /\gamma/ two, and /\iota/ (one of the vowels of the basic triangle) just one. Thus the relative complexity is characterised without the need to invoke metatheoretical ideas such as markedness theory.
The basic reason for the superiority of the dependency notational system over those discussed in earlier chapters is that the difference between pure and mixed vowels, the interpretation of the bleaching and colouring processes, and the notion of relative complexity arise out of the representations themselves. That is, they do not require to be determined externally, nor do they require for their expression the setting up of extra formal apparatus such as markedness theory or hierarchies of applicability of particular phonological processes. Rather, it is inherent in the notational system that these aspects of phonological behaviour can be determined.

The system in (4.29) utilises all the possible simple combinations of the vowel components. However, it is clearly not adequate to account for all the possible vowel systems found in languages. For example, languages with four vowel heights cannot be characterised with the representations of (4.29).

The system can be extended by introducing dependency relationships into the representations, in the same manner as in §4.2. As well as the relationship of the simple combination of \(|i|\) and \(|a|\), we can introduce the possibility of \(|i|\) (asymmetrically) governing \(|a|\), and \(|a|\) (asymmetrically) governing \(|i|\). Similarly, \(|u|\) may govern \(|a|\), and \(|a|\) may govern \(|u|\), to give the representations in (4.34):

\[
\begin{align*}
(4.34) \quad 
\{ |i \not\approx a| \} & \quad \{ |u \not\approx a| \} \\
\{ |a \not\approx i| \} & \quad \{ |a \not\approx u| \}
\end{align*}
\]

The representations in (4.34) allow the extension of the system in (4.29). For example, a ten vowel system with four vowel heights, and series of front unround, front round, and back round vowels, would be appropriately characterised as (4.35):
The various characteristics of the dependency model are retained. Again, the gradual opposition of vowel height is appropriately represented by increase in the prominence of \( \text{\textbar{a}} \) in the representations. As the vowels become lower, so \( \text{\textbar{a}} \) becomes more preponderant in the representations. Similarly, the classificatory properties of the system may also be characterised. The set of high vowels, for example, is the class \{\text{\textbar{a}}\}, i.e. the class of vowels not containing the sonority component, while the class of low vowels is \{\textbar{a}\}, i.e. the class of vowels containing only \( \text{\textbar{a}} \). The set of non-high vowels is \{a\}, i.e. the class of vowels containing \( \text{\textbar{a}} \), while the class of non-low vowels is \{\textbar{a}\}, i.e. the class not containing \( \text{\textbar{a}} \) alone. The class of mid vowels is more complex to express, a fact which should not be surprising, as mid vowels tend to recur less often as a class in phonological processes than the other classes mentioned. An appropriate characterisation might be \{a, \textbar{a}\}, i.e. the class in which \( \text{\textbar{a}} \) occurs with another element. As the class constituted by a particular set of segments becomes less natural, the representation required to characterise it becomes more complex.

Notice that (4.35) does not include any extension of the possible combinations of \( \text{\textbar{a}} \) and \( \text{\textbar{u}} \). Languages do not normally make contrasts among different degrees of rounding of front round vowels; however, it is not apparent from the notational system that combinations of \( \text{\textbar{a}} \) and \( \text{\textbar{u}} \) are so restricted.
(4.35), however, does not represent the maximal number of oppositions of vowel height which are expressible within this notation. If we introduce the mutual dependency relationship, we are able to add another term, to give (4.36) (in which I ignore the possibility of front round vowels):

\[
\begin{align*}
(4.36) \ & \{ |i| \} \quad \{ |u| \} \\
& \{ |i \neq a| \} \\
& \{ |u \neq a| \} \\
& \{ |a \neq i| \} \\
& \{ |a \neq u| \} \\
& \{ |a| \}
\end{align*}
\]

(4.36) represents the maximal possible system involving only combinations of \(|a|\) with \(|i|\) and of \(|a|\) with \(|u|\). Thus there is a claim inherent in the notation that no languages exist in which a larger number of oppositions are found in this area. This claim seems to be correct - there appear to be no languages with more possibilities than those in (4.36). Further, (4.36) is maximally complex in the dimension of vowel height, in that it involves, in addition to the components \(|i|\), \(|u|\), and \(|a|\), both asymmetrical and symmetrical dependency relationships. A system such as (4.35), however (if we ignore the front round vowels), is notationally simpler, in that it lacks the symmetrical dependency relationship. A three height vowel system is again one degree simpler, in that no dependency relationships between \(|a|\) and \(|i|\) or between \(|a|\) and \(|u|\) need to be set up - the relationship of simple combination is sufficient. Thus the notation reflects the complexity of the vowel system in question. In a scalar feature system, however, there is no way of determining whether
a feature with five values is any more or less complex than one with three values. That is, there is no natural correspondence between the number of values and relative complexity, and so there is no way of assessing the relative complexity of any of the vowel systems discussed above.

4.3.1 Processes involving vowels

The various principles which have been established concerning the representations of vowels in dependency phonology allow a more natural expression of the various processes involving vowels which have been surveyed in the previous chapters. I give here an indication of how these processes might be characterised in dependency terms.

As was noted in §1.5, OE i-umlaut appears to involve two sub-parts, shown as (4.37):

(4.37) a. \[
\begin{align*}
&u \rightarrow y \\
&\circ \rightarrow \phi \\
&\partial \rightarrow \partial \\
\end{align*}
\] / \( \_ \_ C_0 \_ \)

b. \( \varepsilon \rightarrow \varepsilon \) / \( \_ \_ C_0 \_ \)

It was seen that distinctive feature theory failed to express this process adequately, on various grounds. It does not show that a single, unitary process is involved (because (4.37a) must be characterised as a change from [+back] to [-back], and (4.37b) as a change from [+low] to [-low]). Further, it fails to show that i-umlaut is a natural process, partly because of the need to introduce markedness theory, which appears to show that the output of the rule is unnatural, in that front round vowels are rated as more complex than front unround vowels.

An interpretation in dependency terms, however, removes these problems. The changes involved are shown as (4.38):
(4.38) a. \(|u| \rightarrow [i, u]|

\(|u \rightarrow a| \rightarrow [i, u \rightarrow a] / \_\_\_ C_0 [i]|

\(|a| \rightarrow [a \rightarrow i]|

b. \(|a \rightarrow i| \rightarrow [i \rightarrow a] / \_\_\_ C_0 [i]|

(where the two parts of the rule are disjunctively ordered).

In (4.38a) and (4.38b), the relationship between the input and the output of the rules is always the same - the output is more |i|-like than the input. Further, the environment of the rule, i.e. the vowel of the following syllable, is \([i]\). Thus the process can be characterised as assimilation towards |i|. If, then, we assume that the change involves addition of an |i| element, we may characterise the individual changes as (4.39):

(4.39) a. \([u] \rightarrow [u]. [i] \rightarrow [i, u]|

\([u \rightarrow a| \rightarrow [u \rightarrow a]. [i] \rightarrow [i, u \rightarrow a]|

\(|a| \rightarrow [a]. [i] \rightarrow [a \rightarrow i]|

b. \(|a \rightarrow i| \rightarrow [a \rightarrow i]. [i] \rightarrow [i \rightarrow a]|

Each change involves addition of \(|i|\), and the segment thus affected moves one step towards |i| (where the exact realisation of the notion 'one step towards |i|' is dependent on the particular characteristics of the Old English vowel system). Thus, /y/ is one degree more |i|-like than /u/. Similarly, /e/ is one degree more |i|-like than /a/. Thus, the adoption of this model allows the process to be characterised as involving a single type of change - movement towards |i| - which is seen to be natural by virtue of the fact that it occurs in the environment of an |i| segment. Further, the output of the change is seen to be more complex than the input in the case of the change from /u/ to /y/, but the process is nevertheless a natural one, on the grounds just given. This change is:

(4.40) \([u] \rightarrow [i, u] / \_\_\_ C_0 [i]|

The relationship between the naturalness of the process and the relative complexity of the output is appropriately characterised by (4.40).

Similarly, the lowering stage preceding ME Open Syllable Lengthening, involving the lowering of all non-low vowels (see (2.17)), is amenable to a dependency treatment. Such a process clearly involves a vowel becoming more |a|-like, rather than more |i|-like:

\[
\begin{align*}
(4.41) \ a. \ & /e/ \rightarrow /e/ & \{ |i, a| \} \rightarrow \{ |i, a|, |a| \} \rightarrow \{ |a \rightarrow i| \} \\
& /o/ \rightarrow /a/ & \{ |u, a| \} \rightarrow \{ |u, a|, |a| \} \rightarrow \{ |a \rightarrow u| \} \\
b. \ & /i/ \rightarrow /e/ & \{ |i| \} \rightarrow \{ |i|, |a| \} \rightarrow \{ |i \rightarrow a| \} \\
& /u/ \rightarrow /o/ & \{ |u| \} \rightarrow \{ |u|, |a| \} \rightarrow \{ |u \rightarrow a| \}
\end{align*}
\]

In each of the changes in (4.41) the output is one degree more |a|-like than the input. Notice that this process involves the creation of a four height system from a three height system, and hence there is a discrepancy in the dependency representations of apparently identical input and output vowels. This matter is not directly concerned with the issue of the characterisation of such lowering processes, and I shall not discuss it any further here (but see for discussion of this kind of problem, with particular reference to MEOSL, Pelt 1979). Rather, the issue is whether the characterisation of the process can show that the input forms a natural class, in view of the fact that a scalar feature system fails to do this. The characterisation in (4.42) seems appropriate:

\[
(4.42) \ \{V\} \rightarrow \{V, |a|\}, \text{ where } V = \{\sim |a|\}
\]

The input class is shown to be natural in that it contains all vowels other than that showing |a| alone.

Finally, I want to return to the vowel harmony process of Turkish, which was discussed in chapter 3 with respect to the theories of prosodic analysis and autosegmental phonology. In Turkish, it will be recalled, only vowels agreeing in backness and roundness can occur in the same polysyllabic word. Only the opposition between high and
low is relevant within a polysyllabic word in Turkish. I suggest that the following treatment of vowel harmony adequately captures the phenomenon.

I shall assume that the type of analysis discussed in chapter 3 is appropriate, i.e. that there are two prosodies or autosegments, whose scope is the whole word. These prosodies, in the dependency model, are |i| and |u|, and may be combined as in (4.43):

(4.43) \(|i| \quad |i\cdot u| \quad |u| \quad \sim |i\cdot u|

These prosodies are specified in the lexical entry of each word, while the vowels in the lexical entries are specified only as low ({a}) or non-low (\(\sim a\)), to give (4.44):

(4.44) a. \(|i| : k \{\sim a\} b\ r \{\sim a\} t \{\sim a\} m \n b. \(|i\cdot u| : g \{a\} z \{\sim a\} m \n c. \(|u| : b \{\sim a\} l \{\sim a\} t \{\sim a\} m \n d. \sim |i\cdot u| : k \{\sim a\} z l \{a\} r

The derivation of the surface forms of the words proceeds as follows. The syllabification and stress rules select the appropriate governors for the words (see §4.1 and chapter 7), to give (4.45):

(4.45) a. 

```
  \(\sim a\)  \\
  \(\sim a\)  \\
  k \quad br \quad t \quad m
```

b. 

```
  a  \\
  \(\sim a\)  \\
g \quad z \quad m
```
(I ignore for the present the problem of the characterisation of consonant clusters - see §7.1 for discussion.)

Next, the appropriate prosody is attached to the node denoting the governor of the word:

(4.46) a.

c.

d.
I suggest that the attachment of the prosody to the governor of a structure denotes that the prosody has as its domain the whole structure in question. Thus, as the stressed syllabic of a word is the governor of that word, the frontness and roundness prosodies in (4.46) have the whole word as their domain. (Notice that there was no way of formalising the domain of a prosody within the prosodic theory discussed in §3.2.) Further, as they are vowel prosodies, their domain extends downwards only as far as the syllabic segments.

Finally, then, the prosodies are 'associated' with the elements within their scope, to give (4.47):
where any negative value is, by convention, suppressed in the presence of a positively specified vowel component. The idea of prosodies having various different structures as their domains, then, can be given a natural interpretation by means of the 'governing' relationship within dependency phonology.

I return to a fuller treatment of the representations of vowels in chapter 8, where I will also discuss in detail the phonetic correlates of the various components, together with the problems of the characterisation of back unround and central vowels.
Chapter 5

The Structure of the Segment

In chapter 3 I surveyed various theories of notation, some of which shared the property that their systems of representation were not of the minimally componential type exemplified by those of Jakobson et al (1952), SPE, and Ladefoged (1971). That is, they did not consist of unordered sets of formally identical components; sets whose only structural difference consisted in a binary or multivalued choice among the values associated with each component. In the dependency representations developed in chapter 4, too, we saw that segments could differ structurally in two ways - in the number of components present in the representation of a segment, and in the dependency relationships, if any, holding between these components.

However, there is another way in which segments might be given a greater degree of componentiality. It is possible that the components making up a segment - be they distinctive features, dependency components, or any other type of unit - should be subdivided into smaller groupings. In other words, a segment can be characterised by a number of sub-groupings, each of which is in turn characterised by a number of components or features. In a componential theory such as this, the segment would have a structure such as (5.1):

\[
\begin{bmatrix}
\text{[ ]} & \text{[ ]} \\
\text{[ ]} & \text{[ ]} \\
\text{[ ]} & \text{[ ]} \\
\end{bmatrix}
\]
in which the number of sub-groupings would depend on arguments such as those to be discussed in §5.2.

In the feature theories discussed in chapter 2, no such sub-grouping was formalised. Indeed, it appears from the nature of the representations in, for example, SPE, that the ordering of the features in a segment is completely random. The characterisation of English /k/ in (1.1) would equally well represent the same segment if any other of the 16! possible orderings of the features was used: more generally, there are $n!$ possible notationally equivalent orderings of the features in a segment, where $n$ is the number of features.

However, although Chomsky and Halle do not formalise the notion of such sub-groupings, they nevertheless appear to suggest that some such idea can be appealed to. The use of terms such as 'major class features', 'tongue-body features', etc., seems to imply an intuitive acceptance of the possibility of sub-groupings. However, the only approximation to a formal device which has the effect of creating sub-groupings is the use of the shorthand notation $N$ for the grouping $\ [+\text{cons}, +\text{nasal}]$.

Standard distinctive feature theories, then, do not display the property of grouping of the features. It has been argued by Lass and Anderson (1975) and Lass (1976) that the greater degree of componentiality afforded by representations such as (5.1) is necessary for an adequate notational system, and they make proposals as to how this might be incorporated. I examine the motivations for these proposals and the nature of the resulting representations in §5.1.

5.1 Arguments for more componentiality

Lass and Anderson (1975) and Lass (1976) produce various arguments supporting the organisation of features into sub-matrices such as (5.1). One of these involves the need to be able to specify sets of homorganic segments in, for example, rules which require the specification of the sequence "any nasal followed by a homorganic obstru-


ent" (Lass and Anderson 1975:263). In a system like that in SPE, this would require a representation such as (5.2):

\[
\begin{pmatrix}
+\text{son} & -\text{son} \\
+\text{nas} & -\text{nas} \\
\text{ahigh} & \text{ahigh} \\
\text{bback} & \text{bback} \\
\text{gamma} & \text{gamma} \\
\text{dant} & \text{dant} \\
\text{ecor} & \text{ecor} \\
\vdots & \vdots \\
\omega F_n & \omega F_n
\end{pmatrix}
\]

However, (5.2), as Lass and Anderson point out, misses the point that what is involved is not "pairwise agreement of arbitrary features" (1975:260), but rather the fact that the location of the oral stricture is identical for both segments, although they differ in 'manner of articulation'. In other words, the features characterising 'place of articulation' are identical for the two segments.

Lass and Anderson argue that instead of representations like (5.2), we require something like (5.3):

\[
\begin{pmatrix}
\alpha & [\text{artic}] \\
[+\text{nas}] & [-\text{obs}] \\
[-\text{obs}] & [+\text{obs}]
\end{pmatrix}
\]

(where the feature [obstruent] characterises the same recurrent class as Chomsky and Halle's [sonorant], but with reverse values).

In (5.3) the two sub-matrices are called the articulatory gesture and the phonatory gesture. Lass and Anderson (1975:263) note:

The phonatory gestures are non-identical [[-obs] vs. [+obs]], and the articulatory gestures are identical except that one is [+nas].

Thus homorganicity is characterised by a Greek letter variable "ranging over any combination of the values '+' and '-' on any feature in the inner brackets, the only condition being that as usual all values covered by any given pair of variables agree" (as in (5.3)). The intuitively obvious fact that what is involved here is agreement in
place of articulation is brought out by (5.3), while (5.2) shows agreement between the values of an apparently arbitrary set of features. (I return below to the motivation for the particular division of the features between the two gestures.)

Thus, a process such as Old English Homorganic Lengthening (OEHL), involving lengthening of a vowel before a sonorant followed by a homorganic voiced consonant, as in (5.4) (from Anderson and Jones 1977:148) might be characterised as (5.5):

(5.4) $[\text{rd}] <\text{sword}>, <\text{word}>, <\text{bord}>
[\text{id}] <\text{ald}>, <\text{bald}>, <\text{cald}>
[\text{rl}] <\text{cherl}>, <\text{erl}>
[\text{rn}] <\text{lern}>, <\text{morn}>, <\text{corn}>

$[V] \rightarrow [W] / \_ _$

(5.5)

((5.4) and (5.5) both characterise lengthening as the epenthesis of a vowel identical to the preceding vowel; i.e. long vowels are treated as geminates. I return to this matter in chapter 8. Note that the fricative in $<\text{erpe}>$ is phonetically voiced, as it is between two sonorants.)

(5.5), then, states that the environment of the rule involves two successive segments with identical specifications for the features of the articulatory gesture, and identical specifications for the features of the phonatory gesture, except for those features which are specified in the rule.

Similar arguments can be established from gemination processes, i.e. processes in which a segment is inserted which is identical in
all features to the preceding segment. The structural change of (5.5) represents such a process. In the minimally componential feature theories, this process would require a specification of the same type as (5.2):

\[
\begin{bmatrix}
\alpha_{obs} \\
\beta_{cons} \\
\gamma_{ant} \\
\delta_{cor} \\
\omega_{F_n}
\end{bmatrix}
\rightarrow
\begin{bmatrix}
\alpha_{obs} \\
\beta_{cons} \\
\gamma_{ant} \\
\delta_{cor} \\
\omega_{F_n}
\end{bmatrix}
\]

(5.6), then, involves the specification of identity between the values of each individual feature in the complete matrix, which, in Lass's terms (1976:164), is "wildly uneconomical". An alternative formulation might be that in (5.7):

\[
\begin{bmatrix}
S.I. \\
S.C.
\end{bmatrix}
\rightarrow
\begin{bmatrix}
1 \\
1 \\
1
\end{bmatrix}
\]

(5.7) (where S.I. is 'structural index' and S.C. 'structural change'). The status of the feature [segment], however, seems problematical; it seems better to express identity between segments as identity between the values of the sub-matrices, as in (5.8):

\[
\begin{bmatrix}
\alpha_{artic} \\
\beta_{phon}
\end{bmatrix}
\rightarrow
\begin{bmatrix}
\alpha_{artic} \\
\beta_{phon}
\end{bmatrix}
\]

The minimal schema (5.8) "defines the notion 'replication of a segment'; the individual instances could be defined by using binary feature specifications as limiting cases" (Lass 1976:166).

Further evidence for the need for representations involving sub-matrices such as these comes from the behaviour of [?]. Lass (1976:145-151) argues that [?] bears "a relation to /pt/ k/ similar to that which [ə] has to the short vowels: it is the 'reduction-stop' just as [ə] is the 'reduction-vowel': it is the neutralisation of the /p/:
/t/:/k/ contrast".
Instead of the complex rules required to characterise the changes /p/ → [?]; /t/ → [?]; /k/ → [?] in the SPE framework, each involving a change of four or five features, as in (5.9) (1976:152):

(5.9) \[
\begin{bmatrix}
+son \\
+ant \\
+cor \\
-cont \\
-voice
\end{bmatrix} 
+ 
\begin{bmatrix}
+son \\
-cons \\
-ant \\
-cor \\
+low
\end{bmatrix}
\]

Lass suggests that what is involved is deletion of all supra-laryngeal articulatory information. That is, one of the two sub-matrices in the representation of the segment is entirely deleted, as in (5.10):

(5.10) \[
\begin{bmatrix}
[oral] \\
-son \\
-voice
\end{bmatrix} 
+ 
\begin{bmatrix}
[cont]
\end{bmatrix}
\]

Glottal stops, then, are seen as "defective", in that they are missing an entire component or parameter that is present in 'normal' segments.

Similarly, [h] is viewed as standing in the same kind of relationship to voiceless fricatives as [?] to voiceless stops. A change from a voiceless fricative to [h], then, involves again the deletion of the supra-laryngeal gesture. Further, [h] is less resistant to complete deletion than the other voiceless fricatives. A sequence voiceless fricative > [h] > 0, for example, is a fairly typical occurrence in historical change. Lass (1976:158) formalises the sequence as (5.11):

(5.11) Full segment + [h] + 0

(e.g. /θ/)

\[
\begin{bmatrix}
+ant \\
+cor \\
+cont \\
-voice
\end{bmatrix} 
+ 
\begin{bmatrix}
[cont]
\end{bmatrix} 
+ 
\begin{bmatrix}
[voice]
\end{bmatrix}
\]

The propensity of [h] to delete is appropriately characterised
by a representation in which it lacks specification for one of the matrices - it is already on its way to 'g'.

Phonetically, too, this seems an appropriate analysis. Pétursson (1972a:106) notes:

La seule possibilité semble alors de définir le [h] [in Icelandic] comme un tronçon de la colonne d'air sur lequel les articulations environnantes se superposent.

Notice, however, that Lass's proposal differs slightly from that of Lass and Anderson. Instead of two gestures labelled [articulatory] and [phonatory], he proposes two gestures labelled [oral] and [laryngeal]. This means that for Lass there are two distinct operations involved in the "de-oralization' of a voiceless stop to [?]" (1976:155) - first, a 'gesture-shift' involving the copying of [-cont] from the oral to the laryngeal gesture, and then deletion of the [oral] gesture as in (5.10); or, in the case of the 'de-oralization' of a voiceless fricative to [h], a gesture-shift in which [+cont] is copied into the laryngeal gesture, with subsequent deletion of [oral]. For Lass and Anderson, however, a feature like [continuant] forms part of the phonatory, rather than the articulatory gesture, and so changes from voiceless stops to [?] involve only the latter stage, i.e. deletion of one of the sub-matrices. In fact, the Lass model is based on the distinction between the two gestures being laryngeal vs. supralaryngeal. In his model, "a vowel schema would be something like this" (1976:153):

(5.12) **Laryngeal gesture:** 'voice'

**Supralaryngeal gesture:**

a. Open approximation to some degree n.
b. Location of closest stricture at some point p on the front/back axis.
c. Some lip attitude (spread, rounded, etc.).

However, he appears to accept that, phonologically, the gestures need not correspond with this division. He suggests that there are two kinds of linguistically relevant information, apportioned between two gestures - (a) a categorial gesture ('vowel', 'voiceless stop'), and (b) a locational or distinctive gesture ('back vowel', 'palatal').
Nevertheless, he does not utilise this distinction in his presentation, and, rather, maintains his convention whereby features may be copied from one gesture to another. Thus, the 'de-oralization' of a voiceless stop to \( [? \] \), as noted above, involves the following two operations (1976:155):

\[
\begin{align*}
\text{(a) Gesture-shift:} & \quad \begin{bmatrix} [-\text{cont}] \\ + \end{bmatrix} \\
\text{(b) De-oralization:} & \quad [\text{oral}] \rightarrow \emptyset
\end{align*}
\]

Lass and Anderson (1975:262), on the other hand, explicitly state that the basic division is not between glottal and supraglottal articulation. Rather, the distinction is on the same lines as those noted by Lass in terms of the categorial/locational dichotomy:

Properties like obstruency, consonantality, and so forth belong to the first gesture, and localized properties like dentalness, etc., belong to the second. We use the cover terms 'phonation' for the first gesture, and 'articulation' for the second.

In this model, then, (5.13) is not necessary. [cont] is already a feature of the phonation gesture, and deletion of the articulation gesture in, say, the change \([t] \rightarrow [?] \) leaves the specifications within the phonation gesture unaffected.

In §§5.2, 6.3, and 7.2, I cite evidence from lenition processes and from syllable structure constraints which appears to show that the Lass and Anderson treatment of this area is more appropriate, even though it deviates from various proposals which have been made with regard to the establishing of gestures or components on phonetic grounds. I return to this matter below.

The proposals made by Lass and by Lass and Anderson in no way exclude the possibility of there being more than two sub-matrices in the representations of segments. For languages other than English, there are various areas which require phonological characterisations which are not dealt with by Lass and Anderson. One major area which must be considered is that of phonation-types other than voiced and
voiceless which may be involved in phonological oppositions - for example, breathy voice and creaky voice. Another major area is that of the airstream mechanisms used in language - pulmonic, glottalic, and velaric. Whatever the nature of the dependency representations which must be established to characterise these phenomena (see chapter 9), we must also decide whether it is necessary to establish new gestures, and if not, in what way the phenomena should be incorporated into the two gestures discussed above.

Irrespective of the possible solutions to these problems, it should be noted that the "notational independence of the two parameters implies that each is a possible proper domain for a phonological rule: in addition to the whole segment being such a domain" (Lass 1976:155). For example, rules affecting the natural class of voiceless stops irrespective of their place of articulation would (at least in the Lass and Anderson model) refer only to the phonation gesture; while, as we have seen, homorganicity can be characterised by reference to a variable over the entire articulation gesture, whatever the features of the phonation gesture.

As we have seen (§3.3), a rather similar proposal is made by Thráinsson (1978:35-36), working within the framework of autosegmental phonology. Thráinsson, like Lass, wishes to treat the set of laryngeal and the set of supralaryngeal features as subsets of "the phonological features composing a phoneme", and also characterises [h] as being specified only for laryngeal, and not for supralaryngeal, features. Thus, the preaspiration rule in Icelandic, which, in Thráinsson's analysis, involves an aspirated stop becoming [h], is characterised as (5.14):

(5.14) 
\[
\begin{array}{c}
{+spr.gl.} \\
{-constr.gl.} \\
{+stiff v.c.} \\
{-slack v.c.} \\
{\text{[C]}} \\
{-son} \\
{-cont} \\
{\text{glab}} \\
{\beta\text{cor}} \\
{\gamma\text{high}} \\
{g}
\end{array}
\]
What is left, then [after deletion of the supralaryngeal features], is simply a segment that has no supralaryngeal feature specification of its own but has the laryngeal specification [+spr.gl., -constr.gl., +stiff v.c., -slack v.c.], and such a segment is an [h] in the Halle and Stevens feature system.

As Thráinsson treats Icelandic /pt k/ as being characterised by the feature specification [+SG], a specification shared by [h], there is no need to have a rule corresponding to Lass's gesture-shift in the characterisation of this process. A similar, although less fully worked out, approach is apparent in Goldsmith (1976a:§4.2).

5.1.1 Phonetic evidence for componentiality

Support for the claim that the segment should be represented as a set of sub-matrices comes from various phonetic aspects of speech-sounds. Phonetically, the production of speech-sounds involves various parameters, which are less atomistic than non-gestural feature theories would suggest. Ladefoged (1971:2-3), for example, distinguishes four processes which are required in the specification of speech - the airstream process, the phonation process, the articulation process, and the oro-nasal process. Catford (1977:15-16), however, suggests that the production of speech involves three functional components, of which two are more basic than the third. The two basic functional components are "initiation (also called 'air-stream mechanism' and articulation)".

By initiation we mean a bellows-like or piston-like movement of an organ or organ-group (an initiator), which generates positive or negative pressure in the part of the vocal tract adjacent to it, that is, between the initiator and the place of articulation. The term 'initiation' is used for this component of speech production since it is the activity that 'initiates' the flow of air essential for the production of almost all sounds. (1977:63).

Articulation is a movement or posture of an organ (an articulator) that interrupts or modifies the air-flow in such a way as to give rise to a specific type of sound. (1977:15). After initiation has set in train a flow of air, articulation acts upon the air-stream to 'shape' it, as it were, into a sound of specific type and quality. (1977:117).
Articulation can be divided into two sub-components - stricture-type and location. Initiation and articulation can be regarded as absolutely basic, since they occur in all speech-sounds - i.e. all sounds are produced on some sort of airstream, and all sounds involve some sort of setting of the articulators. Notice that Catford includes the oro-nasal process as part of the articulation component. The third functional component of speech-production is phonation:

By phonation we mean any relevant activity in the larynx which is not initiatory nor articulatory in function. . . . It is clear that phonation can occur only when we have a column of air passing through the larynx. (1977:16).

Thus all pulmonic sounds, and some sounds produced on a glottalic airstream mechanism, have phonation, while velaric sounds are phonationless. It is because phonation does not occur with all sounds that Catford considers it to be less basic than the other components. Various kinds of phonation are distinguished: for example, vocal-cord vibration, voiceless phonation, whisper, etc.

In view of the arguments discussed in §1.6, it seems clear that we must investigate whether the division of the matrix characterising a segment into phonological sub-matrices should correspond to divisions such as these, which are established on purely physiological phonetic grounds. I take it as desirable that phonological units (of whatever nature) should in principle be able to be mapped against phonetic parameters - whether they be of an articulatory or an auditory/acoustic nature. This view, as noted in §1.6, is in contrast to that of Foley, whose concern is to establish 'purely phonological' systems to which such phonetic criteria are irrelevant. Foley's phonological system, then, is purely abstract. However, although there is an intimate relationship between phonology and phonetics (at least on the view taken here), this does not imply that there is a necessary one-to-one correspondence between the two levels. I take a rather weaker standpoint - that there should be asymmetry between phonological units and phonetic units only where there is convincing phonological evidence that this is necessary. Notice, too, that there is indeterminacy even in phonetic categorisation, depending, for example, on whether articulatory or acoustic properties are being considered.
Anderson and Jones (1977: 5) note:

There may indeed be independent psychological criteria in the internal classification of sound systems, while at the same time what appear at the moment to be purely phonological criteria may turn out to have anatomical or acoustic correlates of which we are as yet ignorant.

Whatever the resolution of these problems may be, it is clear that Catford's phonetic treatment supports the view that the representations of segments should incorporate sub-matrices, thus further increasing the degree of componentiality in the system. Given these considerations, let us see whether the phonological matrix characterising a segment should consist of three sub-matrices corresponding to Catford's three functional (phonetic) components of initiation, articulation, and phonation.

5.2 Phonological gestures

5.2.1 Articulation vs. phonation

It can be seen that the distinction between Catford's articulation and phonation components corresponds more closely to Lass's distinction between an oral and a laryngeal gesture than to Lass and Anderson's distinction between an articulatory and a phonatory gesture. Thus Lass's sub-matrices correspond to Catford's phonetic components. However, this division appears to introduce certain complexities at the phonological level. Principally (in a distinctive feature phonology), [voice] and [sonorant] will form part of the laryngeal gesture, while [continuant] and any other stricture features will form part of the oral gesture. We have already seen that Lass's model involves a 'gesture-shift' in a rule changing a voiceless stop to a glottal stop, and therefore, in this theory, deleting the entire oral gesture. Specifically, [-cont] is shifted to the phonatory gesture, to distinguish [?] from [h] (whose specification also involves deletion of the oral gesture. This appears to be an unfortunate complexity in the phonology.

A more compelling argument against Lass's model is the behav-
iour of segment-types such as voiced and voiceless stops, voiced and voiceless fricatives, and sonorant consonants in various types of phonological hierarchies. In lenition processes, for example, voiceless stops can weaken to voiced fricatives along two paths, either via voiceless fricatives or via voiced stops (see e.g. Lass and Anderson 1975:156-158). In the Lass model, these changes must be viewed as belonging to two different gestures - voicing being a change in the laryngeal gesture, fricativisation a change in the oral gesture:

(5.15) \[
\begin{array}{c}
\text{[-cont]} \\
\text{[-son]} \\
\text{[-voice]}
\end{array}
\rightarrow
\begin{array}{c}
\text{[-cont]} \\
\text{[-son]} \\
\text{[+voice]}
\end{array}
\]

voiceless stop

voiced stop

(5.16) \[
\begin{array}{c}
\text{[-cont]} \\
\text{[-son]} \\
\text{[+voice]}
\end{array}
\rightarrow
\begin{array}{c}
\text{[+cont]} \\
\text{[-son]} \\
\text{[+voice]}
\end{array}
\]

voiced stop

voiced fricative

Sonorisation, too, will involve a change in the laryngeal gesture, while weakening from a sonorant consonant to, say, a semi-vowel is presumably a change in the oral gesture:

(5.17) \[
\begin{array}{c}
\text{[+cont]} \\
\text{[-son]} \\
\text{[+voice]}
\end{array}
\rightarrow
\begin{array}{c}
\text{[+cont]} \\
\text{[+son]} \\
\text{[+voice]}
\end{array}
\]

voiced fricative

sonorant consonant

(5.18) \[
\begin{array}{c}
\text{[+cons]} \\
\text{[+cont]} \\
\text{[+son]}
\end{array}
\rightarrow
\begin{array}{c}
\text{[-cons]} \\
\text{[+cont]} \\
\text{[+son]}
\end{array}
\]

sonorant semi-consonant

vowel

However, there seems to be good reason to treat a set of changes like those outlined above as representing weakening along a single hierarchy (see for example Lass and Anderson 1975:ch.5, Ewen 1977, and
§6.3 below). Lass and Anderson (1975:150), for example, claim that the sequence of changes in (5.19) is one that tends to recur in the histories of languages:

(5.19) (a) (intervocalic) voiceless stop
(b) voiceless stop → voiced
(c) voiced stop → voiced fricative
(d) voiced fricative → approximant consonant
(e) approximant → vowel
(f) vowel → Ø

If schemata such as (5.19) do in fact represent single, unidimensional, recurrent processes, a division between oral and laryngeal gestures disguises the unitary nature of such processes. Features like [continuant], [sonorant], and [voice] seem rather to be of the same phonological type - we might, in Lass's terms, refer to them as categorial features (or, using SPE terminology, as major class features; but notice that Chomsky and Halle consider only [sonorant] to be a major class feature - [continuant] and [voice] do not belong to this set of features (SPE:299)).

Similar evidence can be found in the behaviour of elements in syllabicity hierarchies (see for example Basboll 1974a, Hooper 1976, Vennemann 1972). Like lenition hierarchies, syllabicity hierarchies seem to involve a single scale, on which, in a distinctive feature phonology, the features [voice] and [continuant], for example, interact. Hooper (1976:199) claims that (5.20) represents the intrinsic structure of the syllable:

(5.20)

<table>
<thead>
<tr>
<th>MARGIN</th>
<th>NUCLEUS</th>
<th>MARGIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>obstruents</td>
<td>nasals</td>
<td>liquids</td>
</tr>
<tr>
<td>Least vowel-like</td>
<td>Most vowel-like</td>
<td>Less vowel-like</td>
</tr>
<tr>
<td>STRONG</td>
<td>WEAK</td>
<td>WEAK</td>
</tr>
</tbody>
</table>

The characterisation of the various categories in SPE features would be:
where we again see the features of the two gestures interacting. Again it seems reasonable to suppose that the sequence in (5.20) represents a unitary scale, but a system in which [continuant] and [consonantal] are assigned to one gesture, and [sonorant] to another, fails to show this.

Evidence of this sort (to which I will return in detail in chapters 6 and 7) strongly suggests that the appropriate division between the two phonological gestures does not correspond to that between Catford's articulation and phonation components, but involves, rather, a distinction between, on the one hand, a purely locational gesture, and, on the other, a gesture which combines Catford's phonation component with the sub-division of the articulation component which he labels stricture-type (i.e. manner of articulation). This division is similar to that proposed by Lass and Anderson. What I am claiming, then, is that this gesture involves a set of phonological 'features' which correspond to phonetic parameters of two different types. Thus it seems that a strict adherence to the components established by Catford on phonetic grounds can only disguise the fact that the linguistically relevant distinction between the two gestures is clearly based on other factors.

In fact, however, even on phonetic grounds, it is possible to argue that the association of stricture-type with location rather than stricture-type with phonation is debatable; notice that, as opposed to locational 'features', both stricture-type and phonation 'features' are concerned (at least partly) with characterising the sound-source itself, rather than its modulation or 'shaping' by the vocal tract configuration. This is (roughly) the informal division made between 'source features' on the one hand and 'resonance features' on the other in the Jakobsonian framework.
The label categorial gesture seems more appropriate than the term 'phonatory gesture' which was used in earlier work on dependency phonology (Anderson and Jones 1977, Ewen 1977), seeing that, on the one hand, the gesture does not correspond only to the phonation component of Catford, and, on the other, as we shall see below, some aspects of Catford's phonation component will be assigned to another gesture.

Given the various considerations discussed above, an appropriate representation for [e] might include:

\[
(5.22) \begin{bmatrix}
-\text{high} \\
-\text{low} \\
-\text{back} \\
-\text{round} \\
-\text{cons} \\
+\text{cont} \\
+\text{son} \\
+\text{voice}
\end{bmatrix}
\]

articulatory gesture
categorial gesture

5.2.2 Phonation vs. initiation

I turn now to the division between Catford's phonation and initiation components. Should there be a phonological distinction corresponding to Catford's phonetic one, and if so, should it take exactly the same form?

What I want to suggest is that there should indeed be two gestures in this area, but that there is again good phonological evidence to suggest that the distinction between them is not the same as Catford's phonetic. Specifically, I believe that his phonetic component of phonation should be spread over both the gestures in question. The argument will involve some anticipation of matters dealt with in more detail in chapter 9.

In characterising phonation, Chomsky and Halle use the binary feature [voice] (cf. Jakobson et al 1952). Ladefoged (1971:7-22), however, proposes that what is required is a scalar feature [glottal stricture], which may have up to three values at the phonological level for any particular language, and a number of values at the pho-
netic level. This non-binary feature is required at the phonetic level to characterise the difference between voice, creaky voice, breathy voice, voicelessness, etc., and at the phonological level in those languages which make an opposition amongst more than two states of the glottis - for example, Gujarati, which makes a contrast amongst voicelessness, breathy voice, and voice (1971:17).

It is clear, then, that some means of characterising these various phonation-types is required. However, it is at least possible that the presence in a model of a scalar feature such as Ladefoged's [glottal stricture] does not necessarily imply the absence of a feature corresponding to Chomsky and Halle's [voice]. I have already argued that [voice] is, phonologically, a feature like [continuant] and [sonorant], in that categories like voiced stops and voiceless fricatives appear to behave in the same way with respect to various kinds of hierarchies. However, the important distinction in this respect appears to be between the presence and absence of voice, rather than between various degrees of voicing. This might imply that a feature indicating degree of glottal stricture should be kept separate from one denoting voicing in the more general sense. Notice, too, that a degree of glottal stricture does not necessarily imply [+voice] - whisper (although apparently not used in systematic linguistic communication) shows a greater degree of glottal stricture than voicelessness, but does not involve vocal cord vibration. Phonetically, at least, there are two parameters involved - degree of glottal stricture, and vocal cord vibration.

This is suggestive of a treatment in which there are two phonological 'features' corresponding to the two phonetic parameters. Further evidence can be found which appears to show that the two features should be assigned to different gestures. I suggest that [voice] is a feature of the categorial gesture, while [glottal stricture] (or its equivalent) is a feature of what I shall call the initiatory gesture.

A solution of this sort allows us to capture the notion of phonological complexity in this area in what seems a natural way. In
the phonological representations of segments in languages in which only a voiced/voiceless opposition is found (and in which only a pulmonic egressive airstream mechanism is utilised), the initiatory gesture will be lacking. That is, segments in these languages will require phonologically only bi-gestural representations. For languages in which a three-way opposition in phonation-type is made, and which are therefore phonologically more complex, representations of the initiatory gesture will be present at the phonological level. Thus, the phonological representations for /b/ and */p/ in English (in which only a two-way opposition is made) would involve (5.23):

\[
\begin{align*}
\text{(5.23)} & \quad \begin{bmatrix} +\text{ant} \\ -\text{cor} \\ \vdots \\ +\text{voice} \end{bmatrix} & \quad \begin{bmatrix} +\text{ant} \\ -\text{cor} \\ \vdots \end{bmatrix} \\
\quad & \quad \begin{bmatrix} -\text{cor} \\ \vdots \\ -\text{voice} \end{bmatrix} \\
\quad & \quad \begin{bmatrix} \text{/b/} \\ \text{/p/} \end{bmatrix}
\end{align*}
\]

where only the representations of the articulatory and categorial gestures require to be specified, while the phonological representations of /b/, /b/, and /p/ in Margi would be:

\[
\begin{align*}
\text{(5.24)} & \quad \begin{bmatrix} +\text{ant} \\ -\text{cor} \\ \vdots \\ +\text{voice} \end{bmatrix} & \quad \begin{bmatrix} +\text{ant} \\ -\text{cor} \\ \vdots \\ +\text{voice} \end{bmatrix} & \quad \begin{bmatrix} +\text{ant} \\ -\text{cor} \\ \vdots \end{bmatrix} \\
& \quad \begin{bmatrix} \text{2GS} \end{bmatrix} & \quad \begin{bmatrix} \text{1GS} \end{bmatrix} & \quad \begin{bmatrix} \text{0GS} \end{bmatrix} \\
\quad & \quad \begin{bmatrix} -\text{voice} \end{bmatrix} \\
\quad & \quad \begin{bmatrix} \text{/b/} \\ \text{/b/} \\ \text{/p/} \end{bmatrix}
\end{align*}
\]

(where GS denotes the scalar feature of [glottal stricture]).

The specification of the representations of the initiatory gesture is necessary in (5.24) because of the presence in the language of the opposition amongst three phonation-types. The complexity of such systems in comparison with those in which only a two-way opposition in phonation-type is made is appropriately characterised by this
Notice also that there is a connection between glottal stricture and initiation such that any segment with glottal opening involves a pulmonic egressive airstream mechanism. In languages which utilise a three-way opposition in phonation-type and a two-way opposition in airstream mechanism (whose characterisation will also form part of the initiatory gesture) it seems likely that we will not require separate features to characterise these two properties (i.e. the presence of glottal opening and the presence of the pulmonic egressive airstream mechanism). Specification of an open glottis will in itself characterise the use of the pulmonic egressive airstream mechanism.

Features characterising the other airstream mechanisms (glottalic and velaric) will also form part of the initiatory gesture. These matters are worked out in detail in chapter 9.

5.2.3 The representation of the segment

The matrix characterising the segment will from now on be viewed as a composite of up to three sub-matrices: the articulatory gesture, the categorial gesture, and the initiatory gesture. (5.25) is an abstract matrix showing the kinds of properties present within each of the sub-matrices:

\[
\begin{bmatrix}
\text{place} \\
\text{height} \\
\text{rounding} \\
\text{backness} \\
\text{consonantality} \\
\text{voice} \\
\text{continuancy} \\
\text{sonorance} \\
\text{glottal stricture} \\
\text{glottalicness} \\
\text{velaric suction}
\end{bmatrix}
\]

articulatory gesture

categorial gesture

initiatory gesture

It seems clear that there will be redundancies holding between the gestures. For example, in languages which use more than one airstream mechanism phonologically, the presence of a feature denoting
voicing will make redundant the specification of the feature denoting some degree of glottal stricture other than complete glottal closure (and therefore the specification of a pulmonic egressive airstream mechanism for that segment) in the initiatory gesture.
Chapter 6
The Categorial Gesture

Chapters 4 and 5 were largely concerned with the internal structure of the segment. In chapter 7 I want to consider the structure of sequences in dependency phonology, thus returning to some of the matters raised in §4.1, and this will allow a dependency interpretation of some of the empirically well supported aspects of the various models discussed in chapter 3. However, before this can be done, the dependency representations of the categorial gesture must be established, because, as we shall see, the successful characterisation of sequences such as the syllable depends crucially on the representations of the categorial gesture, in that their internal structure is determined by properties which are characterised by these representations. In this chapter, then, the categorial gesture will be examined, while in chapters 8 and 9, after the discussion of sequences, I shall return to the characterisation of the segment, with respect to the articulatory and initiatory gestures.

6.1 |V| and |C|

Jakobson et al. (1952:18-19) distinguish two 'Fundamental Source Features' - vocalic vs. non-vocalic, and consonantal vs. non-consonantal:

- Phonemes possessing the vocalic feature have a single periodic ('voice') source whose onset is not abrupt...
- Phonemes possessing the consonantal feature are acoustically characterised by the presence of zeros that affect the entire spectrum.

From these definitions, it is clear that vowels are vocalic and non-consonantal, while (true) consonants are consonantal and non-vocalic.
Liquids are characterised as having both the consonantal and vocalic features; i.e. they have some of the acoustic properties of both vowels and true consonants.

For Jakobson et al, these features are, of course, binary (see chapter 2). It seems that the properties characterised by the two features, and the way in which they characterise segments, are indeed appropriate, although they have been interpreted in the dependency model in a rather different way (Anderson and Jones 1977:123). Anderson and Jones propose two dependency components within the categorial gesture - $|V|$, a component which can be defined as 'relatively periodic', and $|C|$, a component with a definition similar to the Jakobsonian consonantal feature, i.e. one whose presence in the representation of a segment correlates with the presence of zeros in the acoustic record of that segment. However, $|V|$ and $|C|$ differ from the distinctive features proposed by Jakobson et al in that the presence of, say, $|V|$ in a segment does not necessarily imply that the segment is in a simple binary opposition to an otherwise identical segment not containing $|V|$. Rather, as discussed in §4.2, the more prominent a particular dependency component in a tree, then the greater is the preponderance of the property characterised by that component for the segment in question. Further, like the vowel components discussed in chapter 4, $|V|$ and $|C|$ can characterise segments either alone or in combination. Thus $|V|$ and $|C|$ have to this extent the same attributes with respect to the categorial gesture as $|i|$, $|u|$, and $|a|$ with respect to the vowel space (i.e. to the articulatory gesture - see chapter 8).

$|V|$ and $|C|$ alone, then, represent either end of a hierarchy, at one extreme of which we find segments with maximum $|V|$-ness and non-existent $|C|$-ness (i.e. maximum periodicity and lack of energy reduction due to the presence of zeros), and at the other extreme segments which show the reverse characteristics - maximum $|C|$-ness and non-existent $|V|$-ness. Vowels are clearly the class of segments within the categorial gesture which show the former characteristics, and voiceless plosives the class which show the latter characteristics. Thus, these two classes have the dependency representations in (6.1) and (6.2):
I turn now to sonorant consonants. Such consonants have traditionally been viewed as being in some way combinations of vowels and true consonants. Jakobson et al characterise liquids, for example, as having both the vocalic and the consonantal features - "like vowels, the liquids have only a harmonic source [hence they are vocalic]; like consonants, they show significant zeros in their spectrum envelope [hence consonantal]". (1952:18). Nasals, too, are seen as combining the characteristics of vowels and consonants: "nasality, by superimposing a clear-cut formant structure upon the consonantal pattern, brings consonants closer to vowels" (Jakobson and Halle 1956: 56). Nevertheless, Jakobson treats nasals as being consonantal, but non-vocalic. Anderson and Jones (1977:124) characterise sonorant consonants as being combinations of $|V|$ and $|C|$, as in (6.3):

(6.3) $\{ |V \neq C| \}$

sonorant consonants

Because "the formant structure of the liquids is broadly similar to that of vowels", we find a representation in which $|V|$ governs $|C|$, rather than one in which $|C|$ (unilaterally or bilaterally) governs $|V|$. Sonorants are characterised, then, as being nearer to the $|V|$ end of the continuum than the $|C|$ end. Compare this too with the SPE treatment, in which nasals and liquids share the feature-value [+sonorant] with the vowels, thus distinguishing this class of segments from the obstruents.

However, it seems clear that, at least phonologically, we need to be able to distinguish the two sub-classes of sonorant consonants - i.e. nasals and liquids - each of which may form a natural class (as opposed to the other) in some phonological process. In acoustic terms, liquids are more $|V|$-like and less $|C|$-like than the nasals; as noted above, Jakobson treats nasals as non-vocalic. Notice that for Jakobson, this leads to problems in characterising liquids and nasals.
as a natural class, which can only be achieved by using the cumbersome formula:

\[
\begin{align*}
(6.4) & \quad \begin{cases} 
+\text{voc} \\
+\text{cons} \\
-\text{voc} \\
+\text{cons} \\
+\text{nas}
\end{cases} \\
\end{align*}
\]

There is a great deal of evidence, however, that nasals and liquids may function as a natural class - see, for example, their behaviour with respect to Dutch diminutive suffix selection (Ewen 1978; cf. the data surveyed in chapter 1, and the fuller account in chapter 11), and to OE Homorganic Lengthening (cf. (5.4)). Indeed, in the SPE feature system, this natural class can be uniquely defined, as [+son, +cons].

I suggest (following Ewen 1977) that the dependency representations in (6.5) and (6.6) reflect these similarities and differences:

\[
\begin{align*}
(6.5) & \quad \{V \not\cong C\} \\
\text{nasals} \\
(6.6) & \quad \{V \not\cong V, C\} \\
\text{liquids}
\end{align*}
\]

In these representations, liquids have an additional subjoined \(|V|\), as compared with the nasals. (Notice that (6.6) differs from any of the vowel representations considered in chapter 4 in that it contains two occurrences of the same component. See below for discussion of the appropriacy of this type of representation.) However, both nasals and liquids involve the sub-structure \(|V \not\cong C|\), and thus the natural class of sonorant consonants is specifiable.

Acoustically, "the constrictive...attenuates the consonantal reduction of energy" as compared with the optimal stop consonant (Jakobson and Halle 1956:55). In terms of the model being developed here, fricatives are therefore less \(|C|\)-like (and consequently more \(|V|\)-like) than their corresponding stops. The following representation for voiceless fricatives can thus be established:
(6.7) \( \{ |V \equiv C| \} \)  

voiceless  
fricatives  

i.e. a representation in which \( |V| \) and \( |C| \) are mutually dependent, and in which the \( |C| \)-ness of the segment is 'diluted' by the presence of a \( |V| \) component. Notice that, like the nasals, the voiceless fricatives have a representation containing both \( |V| \) and \( |C| \). The nasals, however, differ from the voiceless fricatives in having \( |V| \) in governing position - in other words, their representation is more \( |V| \)-like than that of the fricatives, in accordance with their acoustic, and, as we shall see, phonological, characteristics.

"Voiced... phonemes... are characterised by the superimposition of a harmonic sound source upon the noise source of the voiceless phonemes" (Jakobson et al 1952:26). Voicing, then, increases the periodicity of the segment, by virtue of the addition of the harmonic sound source, i.e. vocal cord vibration. Voicing may also be interpreted as involving the addition of a \( |V| \) component, but this time in dependent position, as in (6.8) and (6.9):

(6.8) \( \{ |C \equiv V| \} \)  

voiced  
plosives  

(6.9) \( \{ |V, C \equiv V| \} \)  

voiced  
fricatives  

In that the representation in (6.7) is opposed to those in (6.5) and (6.8), the use of the double-headed arrow notation is appropriate (cf. the discussion in §4.2). In (6.9), however, because of the presence of the dependent \( |V| \), there is no possible ambiguity; as we shall see, there is only one combination of \( |V| \) and \( |C| \) which can either govern or be dependent on another node. We do not, then, have contrasts between, for example, the representations in (6.10):

(6.10) \( \{ |V \equiv C \equiv V| \} \)  

\( \{ |C \equiv V \equiv V| \} \)  

\( \{ |V \equiv C \equiv V| \} \)

As there is no ambiguity involved, I use the form \( |V, C| \) in such circumstances; where voiceless fricatives are characterised, either the double-headed arrow notation in (6.7) or the notation in (6.11) will be used:
Although voiced obstruents are characterised by the addition of a subjoined $|V|$ component, we have seen that sonorant consonants do not show this particular configuration, but rather have $|V|$ alone in governing position (as do vowels). I suggest that this reflects the fact that "voicing must be considered as an accompanying feature of vowels and can be absent only optionally" (Jakobson 1941:69), while for obstruents, voicelessness is basic. "The optimal consonant is voiceless and the optimal vowel voiced." (Jakobson and Halle 1956:56). Like vowels, sonorant consonants are optimally voiced. The representations show that for obstruents voicing is in some sense an additive component, while for sonorants it is inherent.

The distinction between the representations of nasals and liquids ((6.5) vs. (6.6)) can also now be given further motivation. Nasals, like oral stops, are non-continuant, in that they show complete closure in the oral tract (cf. the SPE treatment, where nasals are given the value [-cont]), while liquids are continuant. Further, liquids may form a natural class with fricatives in phonological processes (see, for example, Vaiana Taylor 1974:418-419, Ewen 1977:324-325, and 6.1.1 below). In the representations established here, we see that the non-continuancy of nasals is indicated by the presence of $|C|$ alone in subjoined position (cf. $|C|$ alone in governing position for the plosives), while for the (continuant) liquids, we find subjoined $|V,C|$ (cf. governing $|V,C|$ for the fricatives). However, for both, the fact that $|C|$ and $|V,C|$ respectively are dependent on governing $|V|$ alone shows that they are sonorants.

This treatment of the categorial gesture allows the interpretation of segment-types as being manifestations of different points on the $|V| - |C|$ continuum, whereas binary distinctive feature phonologies must characterise the gradient of the various segment-types by a combination of values for different features. For example, fricatives may differ from stops in being [+continuant], and voiced obstruents from voiceless in being [+voice]. Moreover, as well as being able to characterise the different segment-types as forming in some sense a
'gradual' opposition (Trubetzkoy 1939:75), which, it was claimed in §4.2, was desirable, the dependency system allows us to characterise the types of opposition holding between individual members of this gradual opposition. For example, as we have seen, voiced obstruents differ from their voiceless counterparts in showing an extra subjoined $|V|$. Thus, the opposition between any pair of voiced and voiceless obstruents is shown to be a 'privative' one (Trubetzkoy 1939:75) - the voiced term of this opposition shows a 'mark' which is absent from its voiceless counterpart.

I suggest that the various facts surveyed above lend support to the view, inherent in the treatment within this section, that the 'major classes' of segment-types should be viewed as points on a continuum such as (6.12):

$$\begin{array}{cc}
|V| & \cdots & |C| \\
\end{array}$$

i.e. a continuum, one end of which represents maximum $|V|$-ness, and non-existent (hence minimum) $|C|$-ness, and the other maximum $|C|$-ness and non-existent $|V|$-ness. Notice that (6.12) differs from the kind of representation which could be established with respect to the vowel components of chapter 4, which might have the form:

$$\begin{array}{c}
\text{i.e. a characterisation which does not represent a single continuum, but rather a complex of possible paths. Notice that for each of the components } |i|, |u|, \text{ and } |a| \text{ we can find a path like (6.14) (in which } |X| \text{ denotes any of the three components):}
\end{array}$$

$$\begin{array}{c}
\begin{array}{cc}
|i| & \cdots & |u| \\
\sim |i, u, a| \\
|a| \\
\end{array} \\
\end{array}$$

i.e. a continuum in which one extreme represents maximal $|X|$-ness, and the other non-existent $|X|$-ness, with points in between represent-
ing gradually decreasing $|X|$-ness.

While, by and large, increasing $|V|$-ness correlates with decreasing $|C|$-ness, it would nevertheless be inappropriate to replace (6.12) by a continuum such as (6.14), e.g. by using $|C|$ as the only basic component within the categorial gesture. Such an interpretation of the categorial gesture would preclude the characterisation of the classes as interactions of the two components, linked by the type of dependency relationships developed in this model. Indeed, there would be no other component with which $|C|$ could interact in any way in such a model. Rather, the differences between classes would presumably have to be characterised as difference in 'degrees' of $|C|$-ness; i.e. we would, essentially, have a scalar feature of the type proposed by Ladefoged (1971), and, in particular, Williamson (1977) (see also §6.3 below). This in turn would prohibit the characterisation of the various hierarchical relationships holding between segment classes (to be surveyed in §6.3), and the characterisation of relative complexity (see §6.2).

Thus it appears that, phonologically, (6.12) is an appropriate characterisation for major class segments. Notice, too, that this is given additional support from the fact that, although $|V|$ and $|C|$ occupy opposite ends of a unidimensional scale, they are nevertheless associated with distinct phonetic properties (cf. Jakobsonian vocalic vs. consonantal).

The representations of the categorial gesture differ from those of the articulatory gesture established in chapter 4 in having the structural property displayed by representations such as (6.15):

\[
(6.15) \{ |V \nexists V, C| \} \quad \{ |V, C \nexists V| \}
\]

Such representations display two occurrences of $|V|$, related by unilateral dependency. It seems appropriate to allow just this extension to the types of representations in the dependency system, i.e. to allow two instances of a particular component in a representation, with the further condition that they are linked by unilateral dependency. We shall see that such an interpretation is phonologically ap-
propriate, in that it allows for the expression of hierarchies within
the categorial gesture, and further, this additional structural prop-
erty correlates with the fact that the |V|-ness of a segment may be
increased by different phonetic means, e.g. by addition of vocal cord
vibration (i.e. a harmonic sound source), or by the attenuation of the
consonantal reduction of energy. Thus, while voiced stops and voiced
fricatives differ from voiceless stops and voiceless fricatives re-
spectively in the presence of an additional harmonic sound source,
and fricatives differ from stops in the attenuation of reduction of
energy, voiced fricatives differ from voiceless stops in both re-
spects. It seems appropriate, then, to characterise this difference
by the presence of two extra |V| components in the representation for
voiced fricatives, while the essentially consonantal nature of the
voiced fricatives (as obstruents) is maintained by having |C| in
(mutually) governing position. Notice that in the categorial gesture,
where there are only two components, we require more complex combina-
torial properties, while in the characterisation of the vowel space,
with a greater number of components, only a single occurrence of each
component is permitted in any representation.

6.1.1 Trills, taps, flaps, etc.

I turn now to the consideration of various forms of 'r' and 'l'-
type segments, other than the ordinary sonorant varieties discussed
above. Jakobson et a1 (1952:25-26) notice that "some languages have
a strident counterpart of the phoneme /r/", such as the Czech sibilant
variety of trill, and others have "strident counterparts of the /l/
phoneme". Although such segments show a high degree of formant-damp-
ing, they nevertheless "retain manifest acoustic traces of their rela-
tion to liquids". Jakobson and Halle (1956:56) view the existence of
such strident liquids as reinforcing the consonantal character of the
class of liquids.

It has been argued (Ewen 1977) that such segments must be dis-
tinguishable both from their sonorant counterparts, and from voiced
fricatives - phonologically, they may form a natural class with ei-
ther the sonorants or the fricatives, opposed to the other. In particular, it appears from the process known as 'Aitken's Law' (Aitken 1962, 1975, forthcoming, Lass 1973, 1974, Ewen 1977) that the 'fricative-trill' /r/, which appears in those Scots dialects showing this process, must be given a characterisation which enables it to form a natural class with the voiced fricatives.

Aitken's Law (after the original formulation by Aitken 1962) consists of two processes, both dating from the late 16th - early 17th centuries, and summarised by Lass (1973:14) as:

(6.16) Aitken's Law (a): All long vowels shorten EVERYWHERE EXCEPT before /r v z ə #/.
Aitken's Law (b): All NON-HIGH short vowels lengthen before /r v z ə #/.

These processes took place in many Scots dialects, and leave a system in the modern dialects in which there is no phonemic opposition between long and short vowels in final stressed syllables - rather, the distribution of length is predictable according to the environment (Lass 1974:317).

Lass shows that in the dialects in which Aitken's Law occurs: there are both phonetic and phonological arguments for taking /r/ as a voiced fricative rather than a liquid (1974:338). /r/ in these cases is usually a rather fricative trilled [r], in certain environments even an affricate of the type [dʒ] [i.e. retroflex]... Phonologically, we find that in dialects (like most Southern and Central Scots) which show terminal devoicing of obstruents, /r/ also devoices; but never /l/ or the nasals (1973:17). Thus /r/ classes phonologically with the obstruents (1974:339).

However, within a distinctive feature phonology of the SPE type, it is not possible to characterise an alveolar trilled /r/-type segment in such a way that it can be distinguished both from [j] and from the voiced fricatives. Thus, while the lengthening environment of Aitken's Law might be characterised as (6.17) (using SPE-type features):
i.e. as the class of voiced fricatives, it is not clear what feature will be used to distinguish the fricative trilled [r] from the voiced alveolar fricative [z]. Presumably, some kind of new feature would have to be established (say [trill]) to distinguish the voiced fricatives proper from the fricative-trill, as in (6.18) and (6.19):

Chomsky and Halle (SPE:318), in fact, treat trilled [r] as being produced with 'heightened subglottal pressure'. In their model, this is the only feature which distinguishes [r] from [z]. However, Ladefoged (1971:107) argues that there is in fact no phonetic basis for this distinction, and proposes instead that trills are distinguished from stops and fricatives by a feature [vibration], for which trills have a positive value.

There is also phonological evidence from other languages that the fricative trilled [r] can behave differently from the voiced fricatives. In Czech, for example, /r/ (with both voiced and voiceless allophones) "behaves distributionally like a sonorant" (Kučera 1961:31). This [<Action未曾定义]] (IPA [r]) is defined by Abercrombie (1967:54) as a (voiced) alveolar fricative-trill. In Southern Scots, too, we find dialects in which some sort of breaking process is taking place before /l/ and /r/, but not before fricatives. "In all cases, /r/ is an alveolar trill" (Vaiana Taylor 1974:410-411).

It seems then that the fricative trilled /r/ should have a different representation within the categorial gesture than either the voiced fricatives or the sonorant consonants. In the dependency model, however, we need not introduce a new component to account for segments like these. Rather, we can show their relationship to sonorants on the one hand, and to voiced fricatives on the other, as (6.20):
These segments differ from their sonorant counterparts in having an extra governing \( |C| \), and from voiced fricatives in having an extra subjoined \( |C| \). Notice that they are characterised not as sonorants, but as obstruents (in that they do not show \( |V| \) alone in governing position). As obstruents, then, their voiceless counterparts are represented as (6.21):

(6.21) \( \{ |V, C| \} \)

\begin{align*}
  &\text{voiceless} \\
  &\text{strident} \\
  &\text{sonorants'}
\end{align*}

in which the dependent \( |V| \) characterising voicing is absent. (6.21) is the appropriate representation for the voiceless lateral fricative \( [\text{t}] \) found in many dialects of Modern Welsh in words such as <Llanelly>, and for the voiceless fricative trill \( [\tilde{t}] \) found phonemically in some Welsh dialects in words such as <Rhondda>, and allophonically in Czech (Kučera 1961:34) and Scots (Lass and Anderson 1975:166).

Using the representations established in (6.20) for the voiced fricative-trills, the lengthening environment of Aitken's Law may be specified as (6.22):

(6.22) \( \{ V, C \} \)

i.e. as the set of segments containing \( |V, C| \) in governing position, and (at least) \( |V| \) in dependent position. Similarly, voiced fricative-trills can be shown to form a natural class with sonorants consonants, as, for example, in Czech:

(6.23) \( \{ V \neq V, C \} \)

Further evidence supporting the characterisation of the voiced fricative-trill, and also of the class of liquids as opposed to nasals (see again §6.1) can be found in Vaiana Taylor's comments on the contrasts between the histories of Southern English and Southern Scots.
(1974:418-419). She observes the following differences:

(6.24)  

a. In 15th ME breaking took place before voiceless palatal and velar fricatives, but not in Scots.

b. In Early OE lengthening took place before nasal + homorganic stop clusters and before \( /l/ \). In Scots, only lengthening before \( /l/ \) occurred.

c. In the history of Scots there occurred both vocalisation of \( /l/ \) and lengthening before \( /r/ \), but not in English.

d. In Scots, Aitken's Law lengthened vowels before \( /r/ \) and the voiced fricatives.

She views all these processes as types of '(vowel) strengthening', and points out that Scots evidences strengthening only before segments which are both voiced and continuant. This generalisation can be very naturally captured within the dependency framework. The relevant arguments for strengthening in Scots are the following:

\[
(6.25) \begin{align*}
&\{v \not= v, c\} & \{v, c \not= v\} & \{v, c \not= v, c\} \\
&/l/ & /z/ & /\varphi/
\end{align*}
\]

(voiceless fricatives)

while the two environments which cause strengthening in English, but not in Scots, are:

\[
(6.26) \begin{align*}
&\{v \not= c\} & \{v \not= c\} \\
&/\varsigma/ & /n/
\end{align*}
\]

(voiceless nasals fricatives)

The representations in (6.25) characterise the voiced continuants, and can be distinguished from the representations in (6.26), and indeed from any other segment-type, in a very obvious way. It is only in these three cases that we find a representation containing two \(|V|\)s (which must, according to the constraint observed in §6.1, be related by unilateral dependency). Thus the crucial environment for the strengthening process is:

\[
(6.27) \{v \not= v\}
\]
For a fuller discussion of matters concerned with this analysis of Aitken's Law, see Ewen (1977).

The final class of segments which I shall consider is the class of taps and flaps. Taps differ from trills in that one articulator is thrown against the other by a single contraction of the muscles (Ladefoged 1971:50), while flaps involve "an articulator striking against another in passing while on its way back to its rest position" (1971:51). It is necessary to be able to distinguish taps from trills and approximants, as can be seen from the following set of words in Tamil, taken from Ladefoged (1971:50):

(6.28) a. cam 'saw' arem 'charity' aajam 'depth'

where the three different segments are in parallel distribution.

Ladefoged argues that these sounds should be distinguished by the feature [vibration]: taps, like trills, have a positive value for this feature, while flaps, like stops, have a zero value. Taps and flaps differ from trills and stops in Ladefoged's model in their value for a feature [rate], which, essentially, characterises rapid articulation. Taps and flaps have a positive value for this feature.

It is not clear whether the distinction between tap and flap is phonologically necessary in the categorial gesture. Catford (1977: 128-130) treats both as a sub-type of flap - the 'flick'-type flap (e.g. tapped [c]) and the 'transient'-type flap (e.g. flapped [r]). If the distinction is not necessary, (6.29) seems the appropriate representation for these segments:

(6.29) \{ |C \geq V, C| \}

taps/flaps

The relationship between trills and these segments is shown by the fact that they are identical save for the absence of \(|V|\) in governing position in (6.29). The difference in 'rate' is therefore indicated by the fact that \(|C|\) alone in governing position correlates
with stopness, while $|V,C|$ in governing position correlates with continuancy. (6.29) enables us to show the relationship between stops and flaps in, for example, processes in which stops are realised as flaps in particular environments.

However, (6.29) does not reflect the difference in 'rate' between flaps on the one hand, and stops on the other, although we might argue that the presence of $|V,C|$ in dependent position in the representation of taps and flaps shows this to some extent. The node $|V,C|$ in a tree denotes continuancy in the representations developed so far, and we might argue that the combination of 'stopness' and 'continuancy' (at least for the taps) is appropriately characterised by a representation containing both a $|C|$ node and a $|V,C|$ node. Notice, too, that there is no way of characterising voiceless taps and flaps (unless $|C \neq C|$ is an acceptable representation). However, such voiceless segments are very uncommon, and may not be needed phonologically.

Acoustically, taps and flaps appear to be near the $|C|$ end of the $|V|-|C|$ continuum. They show "considerable reduction of overall level of energy, with some formant-like energy concentration" (Jassen 1962:127).

6.1.2 The categorial representations

The following table illustrates the representations established for the categorial gesture. They are presented in their graph form:

(6.30) $V$

\[
\begin{array}{ccc}
V & | & V \\
\downarrow & & \downarrow \\
V,C & & C \\
\end{array}
\]

vowels liquids nasals

$V,C$

\[
\begin{array}{ccc}
V & | & V,C \\
\downarrow & & \downarrow \\
V & & C \\
vowiced & | & voiceless \\
fricatives & 'strident & sonorants' \\
\end{array}
\]

\[
\begin{array}{ccc}
V,C & | & V:C \\
\downarrow & & \downarrow \\
V,C & & C \\
\end{array}
\]

'vocalic fricatives' 'strident fricatives' 'strident sonorants'
The representations in (6.30) conform with the constraint discussed in §6.1 whereby only one instance of each component per segment is allowed unless the two instances are related by unilateral dependency.

6.1.3 Natural classes

The system in (6.30) allows the characterisation of a number of natural classes of segments. Some major classes that can be distinguished are shown in (6.31):

(6.31) vowels \{\mid V\mid\}
sonorants \{\mid V\mid \uparrow \}
sonorant consonants \{\mid V\mid \uparrow C\}
obstruents \{C \uparrow\}

(\text{where } (\uparrow) = 'unilaterally governing anything or nothing'). Other sub-classes which can be characterised are shown as (6.32):

(6.32) continuant obstruents \{V \leftrightarrow C\}
non-continuant obstruents \{C\}
voiceless obstruents \{C \not\leftrightarrow V\}
voiced obstruents \{C \leftrightarrow V\}
voiced continuants \{V \not\leftrightarrow V\}

(\text{where } \not\leftrightarrow = 'does not govern').

6.1.4 Lateral consonants

In §6.1 I argued that liquids should be given the characterisation \{\mid V \not\leftrightarrow V,C\mid\}, as opposed to nasals \{\mid V \not\leftrightarrow C\mid\}. Within the class
of liquids, the laterals can be distinguished from the non-laterals by means of a component within the articulatory gesture (see §8.9). However, there is evidence from some phonological processes that laterals can, on occasion, form a class with the nasals, opposed to the other liquids. Thus, Ó Dochartaigh (ms a, ms b) notes that in certain dialects of Scottish Gaelic there are various lengthening and diphthongisation processes which operate on short vowels preceding a syllable-final long liquid. He summarises these processes, which operate differently in different areas, as (6.33):

<table>
<thead>
<tr>
<th></th>
<th>Area 1</th>
<th>Area 2</th>
<th>Area 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>bărr</td>
<td>bă:r</td>
<td>bă:r</td>
<td>bă:r</td>
</tr>
<tr>
<td>dall</td>
<td>dal:</td>
<td>daul</td>
<td>daul</td>
</tr>
<tr>
<td>ceann</td>
<td>k′en:</td>
<td>k′eun</td>
<td>k′eun</td>
</tr>
<tr>
<td>cam</td>
<td>kam:</td>
<td>kaum</td>
<td>kaum</td>
</tr>
</tbody>
</table>

It can be seen from (6.33) that in all areas the lateral patterns with the alveolar nasal, while only the non-lateral liquid shows lengthening of the vowel. This leads Ó Dochartaigh to suggest that /r/ has a higher "relative vocalicness" than /l/ and /n/, which in turn are more vocalic than /m/. In terms of dependency representations, he offers the following account:

<table>
<thead>
<tr>
<th></th>
<th>V</th>
<th>V</th>
<th>V, C</th>
</tr>
</thead>
<tbody>
<tr>
<td>V, C</td>
<td>C</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>r</td>
<td>l n</td>
<td>m</td>
<td></td>
</tr>
</tbody>
</table>

where /m/ shows the least [V]-like representation, and /r/ the most [V]-like representation. More generally, Ó Dochartaigh observes that there is phonological evidence from Gaelic to suggest that /l/ is more vocalic than /n/, thus giving the cline /r l n m/.

However, although the representations in (6.34) appear to capture the relationships between the segment-types in Gaelic, we have already seen that the liquids frequently form a natural class opposed to nasals. The adoption of (6.34), then, would mean that different
categorial representations would have to be established for different languages, a state of affairs which might lead to rather ad hoc analyses. It seems appropriate, therefore, to ask whether there is a way of characterising the laterals so that they may be shown to have categorial properties in common both with the other liquids and with the nasals.

Notice that laterals are phonetically unique as far as the categorial gesture is concerned, in having effectively two manners of articulation. While there is closure in the centre of the oral tract, there is also a stricture of open approximation at the sides of the mouth (at least for sonorant laterals). This 'double categorisation' is, however, not captured by the representation \{[V \leftrightarrow V, C]\}. We might argue that an appropriate way of representing this is to allow a characterisation in which the normal constraints on categorial representations (only two occurrences of each component per segment, and only two distinct nodes) is relaxed, as in (6.35):

\[(6.35) \quad \begin{array}{l}
V \\
\mid \\
V, C \\
\mid \\
C
\end{array}\]

In (6.35) the governing \(|V|\) node may be taken to characterise sonorancy, the \(|V, C|\) node continuancy, and the \(|C|\) node the central closure. Thus the various sonorants would have the representations in (6.36):

\[(6.36) \quad \begin{array}{lll}
V & V & V \\
\mid & \mid & \mid \\
V, C & V, C & C
\end{array}\]

<table>
<thead>
<tr>
<th>non-lateral liquids</th>
<th>laterals</th>
<th>nasals</th>
</tr>
</thead>
</table>

Laterals, then, can be shown to form a natural class with the
other liquids, as these are the only segments containing $\{|V \not\in V,C|\}$, or with nasals, as $\{|V \not\in |C|\}$ (i.e. the only segments containing a $|V|$ node superordinate to a $|C|$ node). Thus, the behaviour of the laterals in Gaelic can be characterised within the categorial gesture without resort to the language-specific representations proposed by Ó Dochartaigh. (I ignore here the problem of /m/; it is not clear to me whether Ó Dochartaigh's claim that /m/ is less vocalic than /n/ should be captured by assigning different categorial representations, or whether this is due to the articulatory difference).

Representations like (6.35) would not be required in the phonologies of most languages. That is, in languages in which the laterals form a natural class with the other liquids, and not with the nasals, the representations of §6.1 will be adequate. (6.35) is required only when the phonologically more complex situation found in Gaelic occurs.

Finally, notice that, if necessary, other lateral consonants can be given similar representations. Thus, the various lateral consonants may be characterised as:

\[(6.37) \{ |V \not\in V,C \not\in C| \} \quad \{ |V,C \not\in V,C \not\in C| \} \quad \{ |V,C \not\in C \not\in C| \} \]

\begin{align*}
&\text{lateral} & \text{voiced lateral} & \text{voiceless lateral} \\
&\text{sonorants} & \text{fricatives} & \text{fricatives}
\end{align*}

6.2 Phonological complexity in the categorial gesture

In §6.1, I attempted to justify the dependency representations of the categorial gesture in terms of various phonetic characteristics, mostly acoustic. In the remaining sections of this chapter, I shall argue that various areas of phonological behaviour (in addition to those mentioned already) tend to support these representations. In this section I concentrate on the problem of the relative complexity of segment-types within the categorial gesture.

6.2.1 The Jakobsonian universals

The problem of the representation of relative complexity in pho-
nological segments (see §1.7) is one that has posed great problems for distinctive feature theory, as we have already seen. In a feature-matrix (whether or not we incorporate the proposals regarding multi-gestural representations made in chapter 5), there is no way of representing whether what we are dealing with is a phonologically complex or simple segment, and there is no way of comparing two feature-matrices in terms of relative complexity. Each matrix (at least when fully specified) consists of \( n \) features, each of which has a particular value for the segment in question. As there is no inherent difference in complexity between, say, \([+F_i]\) and \([-F_i]\), or \([OF_m],[1F_m]\), and \([2F_m]\), all segments appear to be equally complex.

I have already shown (in §2.4.1) that the introduction by Chomsky and Halle of 'markedness theory' in an attempt to overcome these deficiencies must fail, irrespective of the success or otherwise of the theory on its own terms. The measure of complexity which can be established using the system does not arise out of the representations themselves, but results from the imposition of external conventions; the theory is basically an attempt to patch up the deficiencies of the representations themselves.

However, the system given in (6.30) shows that certain categorial representations are inherently less complex than others. What must be established is whether the differences between the representations reflect the structural laws which Jakobson establishes.

Jakobson (1941:47) observes:

At the beginning of the first stage of language development, the acquisition of vowels is launched with a wide vowel, and, at the same time, the acquisition of consonants by a forward articulated stop. . . . [As] the dissolution of the linguistic sound system provides an exact mirror-image of the phonological development in child language (1941:60), labial consonants and \( \alpha \) appear to be the last sounds to resist the process of dissolution. (1941:62).

The fundamental nature of this opposition ("minimal consonantismus vs. minimal vocalismus") is reflected in the representations of the two segment-types in the categorial gesture (\(|C|\) vs. \(|V|\)). This is the simplest possible opposition in the system in (6.30), involving
a single \(|C|\) (minimal consonantismus) opposed to a single \(|V|\) (minimal vocalismus).

The first consonantal opposition acquired by the child is that between oral and nasal stop (1941:48), and, together with an opposition between labials and dentals (which is an opposition in the articulatory gesture, rather than the categorial gesture, and is not relevant to the present discussion) forms the minimal consonantal system of the languages of the world. Jakobson interprets this opposition - the first paradigmatic opposition - as being the natural one, involving an "open subsidiary cavity in addition to the obstructed cavity, i.e. the open nasal cavity is joined to the obstructed oral cavity, and thereby combines the specific characteristics of the stop sound and the vowel". This is "the most resistant [paradigmatic opposition] in aphasia" (1941:72). The nasals have a comparatively simple representation in (6.30), involving only \(|V \div C|\).

I turn now to Jakobson's consideration of liquid consonants.

The number of languages with a single liquid (whether \(l\) or \(r\)) is extraordinarily large, ... and the child has only a single liquid for a long time and acquires the other liquid only as one of his last speech sounds. (1941:57).

Further, the distinction "is one of the earliest and most common losses in aphasic sound disturbances" (1941:60).

These comments provide further evidence for giving nasals and liquids different representations (see §6.1). Notice that the representation for liquids is more complex than that for nasals, in that it contains an extra subjoined \(|V|\). This correlates with the fact that liquids are a later acquisition, are lost earlier in aphasia, and with the fact that an opposition between two liquids (e.g. /l/ vs. /r/) is much rarer than an opposition between two nasals (e.g. /m/ vs. /n/). In short, the liquids, in Jakobson's terms, occupy a higher stratum than the nasals, and "the general laws of irreversible solidarity" predict that the acquisition of a higher stratum demands the previous acquisition of a lower stratum, while the loss of a lower stratum demands the previous loss of a higher stratum.
I have noted that the first obstruent acquired (i.e. the one which occupies the lowest stratum) is the voiceless stop. We must now examine the relationship of the other obstruents to the voiceless stops in the various areas under examination.

The acquisition of fricatives presupposes the acquisition of stops in child language; and in the linguistic systems of the world the former cannot exist unless the latter exist as well. Hence, there are no languages without stops, whereas... [there are] languages in which fricatives are unknown.... In aphasics,... fricatives fall together, as in children, with the corresponding stops. (Jakobson 1941:51, 61).

Clearly, then, fricatives appear to occupy the next higher stratum from stops - notice that "the child first changes fricatives to the corresponding stops" (1941:52) (and vice versa in language dissolution), rather than to any other segments.

As far as the relationships between voiced and voiceless obstruents is concerned, Jakobson notes:

The voiced consonants have become devoiced, as is customary in aphasics (1941:63). The consonant is generally voiceless in the beginning stage of child language, and loses its voicing in partial sound-muteness. In partial sound-dumbness the voiceless rather than the voiced consonants are recognised. Similarly, in the languages of the world in which there is no phonemic opposition of voice vs. voicelessness, either only voiceless consonants occur or, at least, the voiceless consonants function as basic variants. (1941:70).

We see, then, that voiced obstruents must occupy a higher stratum than their voiceless counterparts.

However, no claims are made as to the relative position in this stratification of the voiceless fricatives and the voiced stops - that is, there appears to be no structural law holding such that in, say, language acquisition, the acquisition of the one presupposes the acquisition of the other, or that in aphasia, the loss of one presupposes the loss of the other. Similarly, languages of the world seem to be able to have either or both of these two phonological categories.

These observations are reflected in the dependency representations in (6.38):
The representations of both the voiceless fricatives and the voiced stops contain a single |V| and a single |C| - i.e. like the nasal consonants, the simplest possible representations incorporating more than a single basic element. In other words, the representations of the segments occupying the next stratum up from the voiceless stop are minimally different from the representation of the voiceless stop.

On the next stratum we find the voiced fricatives, whose representation is correspondingly more complex, involving an extra |V| as compared with the voiced stop and the voiceless fricative - in relations to the voiced stop, the extra |V| is in governing position, to denote continuancy, while in relation to the voiceless fricative, it is in dependent position, to denote voicing. Again, the relative complexity of the segment, as defined by Jakobson's law, is reflected in its representation.

We can represent the stratification of the segments discussed so far as (6.39):

\[(6.39) \{ |V \neq V, C| \} \quad \{ |V, C \neq V| \} \]

\{ |V \neq C| \} \quad \{ |V \neq C| \} \quad \{ |C \neq V| \}

\{ |V| \} \quad \{ |C| \}

In (6.39) the opposition denoted by the unbroken line is fundamental. All other oppositions (indicated by broken lines connecting the two segment-types in question) depend on the presence of the previous opposition in the direction of the fundamental opposition.
It will be noted that, like Jakobson, I treat all oppositions (other than \{V\} vs. \{C\}) as consonantal oppositions, deriving from \|C\|, rather than from \|V\|. I assume that this correlates with the basic distinction between vowels and consonants in language - i.e. all segment-types (except \{V\} and \{C\}) are treated as sub-types of \|C\|.

An interesting aspect of (6.39), which will assume some significance in a moment, is that on each path, to get from a segment-type on a lower stratum to a segment-type on a higher stratum, we add a \|V\| to the tree. Further, there are three paths diverging from \|C\| - that is, there is no structural law holding between, for example, nasals and voiceless fricatives.

I turn now to what appears to be the most complex representation in (6.30), that for the voiced 'strident sonorants', which show the representation \{V, C \neq V, C\}. Jakobson (1941:58) notes:

Czech /\xi/, a sibilant opposition to /r/, is one of the rarest phonemes that occur in language, and hardly any other phoneme of their native language presents such major and persistent difficulties to Czech children.

Clearly, then, this representation seems appropriate for the segment as it appears to occupy a higher stratum than any of the segments in (6.39), and, presumably, its acquisition or presence in a language depends on the presence both of a liquid and of a voiced fricative. And again, to get from the representations for liquids and for voiced fricatives to that for /\xi/, we have to add a component, which is this time, however, \|C\|.

The voiceless counterpart of this segment-type is represented by \{V, C \neq C\}, and appears to have a simpler representation (lacking the dependent \|V\| denoting voicing). However, a sound like /\xi/ appears to be very rare - even rarer than its voiced counterpart /\xi/. This appears to present a problem for the thesis that complexity is directly reflected in the representations. However, the representations for 'strident sonorants' - both voiced and voiceless - differ from other representations, in that they cannot be approached by adding a single \|V\| to any representation previously established.
Rather, they can only be approached by increasing the prominence of \(|C|\) - in the case of the voiced set by adding \(|C|\) to the representations for liquids or voiced fricatives, and in the case of the voiceless set by deleting \(|V|\) from the representation for the voiced set. Relative complexity, then, can be viewed not only in terms of the number of basic components in the representation, but also in terms of the type of path connecting one segment-type to another segment-type: a path which involves increase in prominence of \(|C|\) appears to be relatively more complex than one involving increase in prominence of \(|V|\).

I assume, then, the following schematisation of Jakobson's stratification of the different types of segment:

(6.40) \[
\{ |V, C \neq C| \} \\
\{ |V, C \neq V, C| \} \\
\{ |V \neq V, C| \} \\
\{ |V \neq C| \} \\
\{ |C \neq V| \} \\
\{ |V| \} \quad \{ |C| \}
\]

(It will be noted that in (6.40) I ignore the representations of the taps and flaps. I am not aware of evidence which would indicate the appropriate position of such segments in (6.40).)

(6.40), then, formalises the notion of the complexity of phonemic categories (Jakobson 1941:91), with respect to their dependency representations. Notice that it is very difficult to achieve the same degree of transparency using a distinctive feature system such as that proposed in SPE. In a language utilising all the segment-types in (6.40), Chomsky and Halle would require something like (6.41):
Each new opposition (moving from the bottom to the top of the diagram) can be characterised by the addition of one (or more) additional feature, but the nature of the feature in any particular case does not appear to correlate in any obvious way with the considerations outlined above - specifically, there appears to be no formal reason why the features should appear in the particular order above.

Jakobson (1941:91) notices:

The more complex a phonemic category is, the weaker is its capacity to split, the more rarely does it split in the languages of the world, the later does this split occur in child language, and the more easily is it given up by aphasics.

Languages, then, characteristically have oppositions among the voiceless stops, the vowels, the nasals, and the other obstruents. However, "the distinction of l and r, and ... the incomparably more exceptional distinction of r and ð" is much rarer. Within the model under discussion, the capacity to split represents the number of different types of articulatory gesture which can be associated with each type of categorial representation. Thus, amongst the simplest categorial types (i.e. voiceless stops and vowels), we find a large number of articulatory possibilities, while there tend to be fewer possibilities amongst the more complex categorial types (e.g. voiced fricatives and liquids).
It appears, then, that there is an inverse relationship between the two gestures. The more complex the categorial gesture, the less complex the articulatory gesture can be - i.e. the number of oppositions which can be contracted within the articulatory gesture associated with a particular categorial gesture (and hence the complexity of that articulatory gesture) depends on the complexity of the categorial gesture.

6.2.2 Markedness in the categorial gesture

Markedness theory, as noted above, has been criticised on various grounds, and I will not repeat all the relevant arguments here (cf. again §3.1). What I wish to point out, however, is that the criticisms made of markedness theory relate primarily to the assumption that some segments are non-normal in an absolute sense. However, as Lass (1972:61) remarks, the choice of members of the phonological inventory of a language:

is ... of an implicational (dependency-based) rather than a hierarchical structure. ... The hierarchy ... will consist of a set of necessary choices which appear to be universal, and a larger (unordered) set of contingent choices which any language can make after it has made the non-contingent ones.

Lass argues that this view, "very like the Praguean notion of 'marking'", incorporating implications such as 'if $m$, then $v'$, might lead to a minimal hierarchy like (6.42) (in which I show only features relevant to the categorial gesture):

(6.42)

As in the diagram illustrating the distinctive feature interpretation of the Jakobsonian structural laws, the choice of features in
(6.42) seems quite arbitrary. However, a counterpart of (6.42) in the dependency model gives (6.43):

\[
\begin{align*}
\{v\} & \quad \{v \Leftrightarrow c\} \\
\{c\} & \quad \{v \Leftrightarrow c\}
\end{align*}
\]

in which the minimally complex status of the segments involved is clearly brought out. Anything below the minimal hierarchy in (6.43) would have a more complex representation.

6.3 Hierarchies in the categorial gesture

There have been various proposals for a hierarchical ranking of segment-types in phonological theory, both in terms of 'manner of articulation' (and voicing), and 'place of articulation'. What I am concerned with here is the first type, i.e. proposals which have been made for hierarchies of segment-types within the categorial gesture. The evidence for the need for such hierarchies has been drawn from various phonological phenomena, and the phonetic correlates of the hierarchies have been interpreted in various ways.

A number of phonologists have established hierarchies on the basis of historical changes, such as 'lenition' processes. For example, Foley (1977) sets up various scales of 'relative phonological strength' or 'phonological parameters' on the evidence of changes such as consonants shifts in German and Spanish, and changes in the history of various other languages (1977:28-32,35-59). Foley's parameters have no direct phonetic correlates, since "the elements of a phonological theory must be established by consideration of phonological processes, without reduction to the phonetic characteristics of the superficial elements". Examples of Foley's parameters are the '\( \beta \)-parameter' in (6.44) (1977:145):
Voiced spirants stops spirants nasals liquids glides vowels

<table>
<thead>
<tr>
<th></th>
<th>voiced spirants</th>
<th>voiced stops</th>
<th>voiceless stops</th>
<th>voiceless aspirates affricates double stops</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

and the 'p-parameter' in (6.45):

Voiced spirants stops spirants nasals liquids glides vowels

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
</table>

Vaiana Taylor (1974:406) draws her evidence from changes in the history of Scots, and proposes two scales, which are the inverse of each other - a sonorance scale, in which increasing strength is equivalent to increasing acoustic energy, and a consonant scale, in which increasing strength is equivalent to increasing articulatory resistance:

(6.46) Proposed sonorance scale

In order of increasing strength: voiceless stops, voiceless fricatives, voiced stops, voiced fricatives, liquids, consonantal approximants, vowels, long vowels.

Sonorance scale: t s d z l j l l

strength = acoustic energy

Consonant scale: l l i j l z d s t

strength = articulatory resistance

Lass and Anderson (1975) view 'lenition processes' as weakening along a hierarchical ranking of consonants originating from the strongest type. There are two types of lenition: "opening, i.e. progressive continuantization without change of glottal attitude, and sonorization, i.e. voicing and then progressive opening, with increasing output of acoustic energy" (1975:159). (For a fuller discussion, see §6.4.)

Finally, Escure (1977:60) sets up the following universal "hierarchy of major class and manner features... mostly based on Germanic and Romance data":
Other phonologists have established similar scales and hierarchies using evidence from synchronic phonological processes rather than historical change — although there is of course a great deal of overlap in this area. Zwicky (1972: 277) establishes a hierarchy of segment-types according to their behaviour in various fast-speech phenomena in English:

(6.48) Vowels Glides [r] [l] [n] [m] [ŋ] Fricatives Stops

Hankamer and Aissen (1974) discuss a number of assimilation processes in Pali, and propose a "new kind of 'feature', sonority - which may take a range of values" (1974: 137). The ranking along this scalar feature in Pali is:

(6.49) stops s nasals l v y r vowels
1 2 3 4 5 6 7 9

Vennemann (1972) and Hooper (1976, 1977) are concerned with setting up strength hierarchies on the basis both of historical change and of synchronic rules, in particular rules of syllabification and of syllable structure. Vennemann (1972: 6) proposes the following tentative strength scale of consonants in Icelandic:

(6.50) 1 2 3 4 5 6 7 8 strength
\[ j \quad r \quad l \quad m \quad f \quad s \quad p \quad t \]
\[ v \quad n \quad b \quad k \quad d \quad g \]

Hooper (1976, 1977), surveying a wider range of data, establishes the following 'universal strength hierarchy', which is in all relevant respects identical to that of Escure (1977):
Although the evidence for setting up strength hierarchies like these is clear (for some further discussion on lenition and syllable structure see §§6.4 and 7.2, and for a general discussion of the need for hierarchies in phonology Drachmann 1977), the major problem that has arisen is how strength hierarchies (or sonority hierarchies) are to be formalised in distinctive feature phonologies. Among the solutions proposed is that of Hankamer and Aissen (1974) mentioned above, in which a multivalued feature of sonority is introduced.

Vennemann and Ladefoged (1973) propose a system of cover features in addition to the normal 'prime features'. Segments with particular values for prime features such as [stop] and [fricative] in (6.52) will also have a particular value for the cover feature [strength]:

\[
(6.52) \quad [\text{3 strength}] \leftrightarrow [+\text{stop} \quad -\text{fricative}] \\
[\text{2 strength}] \leftrightarrow [-\text{stop} \quad +\text{fricative}] \\
[\text{1 strength}] \leftrightarrow [-\text{stop} \quad -\text{fricative}] 
\]

where \(\leftrightarrow\) is to be read as 'is equivalent to'. The value for the cover feature can be predicted from the values of the prime features by a set of 'feature redundancy rules' (1973:69).

Various other proposals for scalar features accounting for what are essentially different manners of articulation also go some way towards formalising these observations. For example, Ladefoged's (1975) multivalued feature [stop] has three values [stop], [fricative], and [approximant], while Williamson's (1977) n-ary feature [stricture], which she establishes on the basis of historical changes in various languages, has the following values:
However, such features are by themselves not adequate to account for all the positions in, for example, Hooper's universal strength hierarchy (6.51) - in that, for example, nasals are not distinguished from other segment-types.

Basbøll (1974a, 1977) sets up a hierarchy, not of segment-types, but of distinctive features. This hierarchy is meant to account for possible syllable structures in languages, and I will discuss it in detail in §7.2.

There appear to be two major difficulties in relation to the formalisation of strength relationships between segment-types in a distinctive feature phonology. The first is that if a multivalued or scalar feature of strength (or sonority, etc.) is adopted instead of binary features such as [continuant], [voice], [sonorant], etc., it becomes impossible to characterise naturally privative or equipollent oppositions such as that holding between obstruent and sonorant consonants. For example, Williamson (1977) would presumably characterise the opposition between obstruents and sonorants as:

\[
(6.54) \ [\geq 1 \text{ stricture}] \text{ vs. } [\leq 0 \text{ stricture}]
\]

a formulation which disguises the binary nature of the opposition. Vennemann and Ladefoged's proposal for a cover feature [strength] in addition to the prime features such as [stop] and [fricative] allows a formal expression of the scalar strength relation while maintaining the possibility of expressing binary relations (albeit at the expense of proposing a much weaker hypothesis concerning phonological structure). However, like all the other approaches discussed, it fails to solve the second problem, which is that the order of segments on the scales discussed seems to be quite arbitrary in a distinctive feature phonology. For example, why, in Vennemann and Ladefoged's formulation, should [+stop, -fricative] be stronger than [-stop, -fricative]?
Similarly, formalisms like those in (6.55) (proposed by Vennemann—see Hooper 1976:207) are not predicted by the notation to be more natural than if the values were reversed:

\[(6.55)\]

- \[\text{strength } (\begin{array}{c} A \\ \text{-} \text{voice} \end{array}) > \text{strength } (\begin{array}{c} A \\ \text{+} \text{voice} \end{array})\]
- \[\text{strength } (\begin{array}{c} A \\ \text{-} \text{sonorant} \end{array}) > \text{strength } (\begin{array}{c} A \\ \text{+} \text{sonorant} \end{array})\]
- \[\text{strength } (\begin{array}{c} A \\ \text{-} \text{continuant} \end{array}) > \text{strength } (\begin{array}{c} A \\ \text{+} \text{continuant} \end{array})\]
- \[\text{strength } (\begin{array}{c} A \\ \text{+} \text{tense} \end{array}) > \text{strength } (\begin{array}{c} A \\ \text{-} \text{tense} \end{array})\]

and where \(A\) is \([\text{+} \text{sonorant}]\):

\[\text{strength } (\begin{array}{c} A \\ \text{+} \text{nasal} \end{array}) > \text{strength } (\begin{array}{c} A \\ \text{-} \text{nasal} \end{array})\]

While (6.55) may describe the relations correctly, the distinctive feature representations fail to show why this should be. Consider now the elements in a strength hierarchy in terms of the dependency representations developed in §6.1:

\[(6.56)\]

\[
\begin{align*}
\text{vowels} & \quad \text{liquids} & \quad \text{nasals} & \quad \text{vd conts} & \quad \text{vl conts} & \quad \text{vl stops} \\
\{ |V| \} & \quad \{ |V \neq V, C| \} & \quad \{ |V \neq C| \} & \quad \{ |V \neq C, V| \} & \quad \{ |V \neq C, C| \} & \quad \{ |C| \} & \quad \{ |C \neq V| \}
\end{align*}
\]

strength

The relationship between each element on the strength hierarchy is obvious. As an element becomes stronger, it becomes more \(|C|\)-like, and therefore less \(|V|\)-like, and vice versa as it becomes weaker. In a dependency phonology, there is no need to set up an independent 'feature' of strength, as the hierarchy is inherent in the segmental representations. Thus the problem of the apparent arbitrary relationship between the feature representation of segments and their relative position in the hierarchy is overcome. Similarly, there is no problem in expressing binary oppositions holding within the hierarchy -
the privative opposition of voiced vs. voiceless (for obstruents) is characterised by the presence of dependent \( \mathcal{V} \) vs. its absence, while the opposition of sonorant vs. obstruent is characterised by a single governing \( \mathcal{V} \) vs. a governing \( \mathcal{C} \) (either alone or in a relationship of mutual dependency). For further discussion, see Ewen (1977:326).

Having shown that the formal problems of characterising the concept of hierarchies in the categorial gesture do not arise in dependency phonology, I now wish to examine in greater detail two areas in which such hierarchies are relevant. In the following section, I examine the area of lenition processes in language, while in §7.2 I shall deal with the internal structure of syllables.

6.4 Lenition processes

As we saw in §6.3, Lass and Anderson (1975:159) suggest that:

In lenition processes there are two basic options (assuming a hierarchical ranking where we start with a voiceless stop as the strongest type): opening, i.e. progressive continuantization without change of glottal attitude, and sonorization, i.e. voicing and then progressive opening, with increasing output of acoustic energy. The last stage in any lenition is deletion: though this is not to say that all deletion is the result of lenition.

These options, then, are realised by "sequences of changes that tend to repeat themselves again and again in the histories of languages" (1975:150), and can be represented as (6.57) and (6.58):

(6.57) Weakening of closure: no glottal change

4. Voiceless t
3. Spirantized s
2. Dearticulated h
1. Deleted Ø

(6.58) Sonorization and opening

7. Voiceless t
6. Voiced d
5. Spirantized z
4. 'Liquid' r
3. Approximant j, j
2. Vowel l
1. Deleted Ø
However, these two hierarchies are not entirely distinct. A voiceless stop, for example, may weaken to a voiceless fricative (4→3 in (6.57)) by weakening of closure, and then become a voiced fricative (5 in (6.58)) by sonorisation, rather than via a voiced stop (7→6→5 in (6.58)). In Ewen (1977:319), (6.57) and (6.58) are collapsed to give (6.59):

(6.59) Voiceless d t z s Spirantized
Voiced
Spirantized 'Liquid'
Approximant Vowel Deleted

As noted above, Lass and Anderson do not claim that progressive lenition involves all the steps in (6.59), but rather that lenition will involve movement along the scale in the order given. For example, they note the following development:

(6.60) pre-OE OE ME late ME
/-g-/ > [-γ-] > [-w-] > ([-u-]) > Ø
[*aagan] [aayan] [ɔwən] [ɔɔn] 'own'

Notice that in (6.59) I have ignored the dearticulation stage of (6.57). In terms of the multi-gestural model developed in chapter 5, this stage differs from the others in involving deletion of the articulatory gesture, rather than a change in the categorial gesture. Lass (1976:163) proposes a universal 'progressive lenition schema' for obstruents:

(6.61) Progressive obstruent weakening

Weakening I: feature change
[-cont] → [+cont]

or
[-voice] → [+voice]

Weakening II: matrix change
[[oral]] → [g] → [g]

I postpone further discussion of the 'matrix change' part of
lenition until §6.4.2.

In (6.61), we see that although lenition appears to be a unitary phenomenon, in that it involves movement along a hierarchy such as those discussed in §6.3, a distinctive feature phonology requires a choice between two apparently unrelated features, [cont] and [voice], to characterise weakening in obstruents. And the situation becomes worse if we consider the rest of the stages in (6.59). Presumably, the change from [z] to [r] involves a change from [+obs] to [-obs] (or [-son] to [+son]), while the change from sonorant consonant to vowel involves [+cons] becoming [-cons]. 'Weakening I' in (6.61), then, if we are to extend it for use as a schema for progressive lenition in general, would take the form in (6.62):

(6.62) Progressive weakening

I: feature change
[-cont] → [+cont]

or
[-voice] → [+voice]

or
[+obs] → [-obs]

or
[+cons] → [-cons]

(6.62), with a choice among four feature changes, can hardly be said to reflect the unitary nature of lenition (cf. (6.55) above with reference to strength relations).

However, if we consider the dependency components |V| and |C| to represent either end of a linear scale, it is clear that each of the changes in (6.62) are manifestations of the same kind of process. All involve movement along the scale in the direction of |V|, and therefore away from |C|. Lenition, then (insofar as Lass's category 'feature change' is concerned), involves a change in the direction of |V|, or "progressive suppression of |C|" (Anderson and Jones 1977:125). Similarly, 'strengthening', as noted in §6.3, involves a change in the direction of |C|. For example, the strengthening of voiced obstruents
to voiceless in final position involves the segment becoming more |C|-like (specifically by deletion of the subjoined |V| denoting voicing); cf. Vaiana Taylor (1974:404).

The interpretation of lenition as a shift towards |V| is illustrated in (6.63), which is equivalent to (6.59), and utilises the representations established in §6.1:

(6.63) $\rightarrow \rightarrow \rightarrow$

(6.63) is the equivalent for historical change of the universal strength hierarchy presented in (6.56). Thus the dependency interpretation of the historical English changes in (6.60) can be represented by the following schema:

(6.64) $\rightarrow$ $\rightarrow$ $\rightarrow$ $\rightarrow$

However, (6.63) can be extended to take account of the various other segment-types in (6.30). The 'strident sonorants' discussed in §6.1.1 appear to be able to undergo various kinds of lenition processes. The voiced strident sonorants ([f] and [b]) typically weaken to their corresponding sonorants ([j] and [l]). The change of [f] to [j] has occurred in many Scots dialects. The voiceless phoneme /t/ found in Welsh has, in some parts of the country, weakened to its voiced counterpart /t/, while [s] often appears to weaken to the sonorant [l], either directly, or through a [b] stage.

A further example which can plausibly be interpreted as lenition is the behaviour of Spanish /f/ (/r/) [f] <rr> in fast non-energetic speech (Harris 1969:46-47, Hooper 1976:211-212). In certain environments (before a vowel, either word-initially or intervocally), this phoneme is realised as a fricative, which Harris represents as [z] (see also Navarro Tomás 1932:124). Jakobson, too, in his discussion of Czech /r/ (which has allophones [f] and [ɔ]) cites
the case of Czech settlers in Russia, where loss of these sounds occur, and "the voiced combinatorial variant becomes ʒ, the voiceless ⟨ʃ⟩" (1941:58).

These various lenition processes can be schematised as (6.65):

\[
(6.65) \quad \{V, C \Rightarrow V\} \quad \{V \Leftrightarrow C\} \quad \{V, C \Rightarrow V, C\}
\]

Again, in all cases lenition involves an increase in the \(|V|\)-ness of the segment-type.

We are now in a position to examine more closely the nature of the 'movement towards \(|V|\)' inherent in lenition. I suggest that each step in a general lenition process such as (6.59), (6.63), and (6.65) is a realisation of one of three processes:

\[
(6.66) \quad (a) \text{ addition of single } |V| \\
(b) \text{ alteration of dependency relationships such that the new segment contains the same basic elements, but is } |V|-er \text{ than before} \\
(c) \text{ deletion of single } |C|
\]

Further, (a)-(c) represents a 'preferred' order. For example, lenition of a voiceless fricative \(|V \Leftrightarrow C|\) does not involve deletion of \(|C|\) (the least preferred option), which would involve lenition directly to \(|V|\) alone, but rather addition of \(|V|\), to give a voiced fricative, i.e. one step along the lenition hierarchy (cf. the relations holding between the segment-types in the hierarchy of acquisition (6.40)).

In general, less preferred alternatives are implemented only
when the preferred alternative is not available. For example, leni-
tion of a voiced fricative {\(V,C \nRightarrow V\)} cannot involve alternative (a) (because there are already two \(V\)'s), and so instead alternative (b) applies, to give \{\(V \nRightarrow V,C\)\}, with the demotion of \(\mid C\) to the depend-
ent node. Similarly, weakening of \{\(V,C \nRightarrow V,C\)\} must involve (c), and yields either \{\(V \nRightarrow V,C\)\} or \{\(V,C \nRightarrow V\)\}, depending on which \(\mid C\) is deleted.

I have made no mention of the nasals with respect to lenition. Clearly, nasals do not participate in either (6.64) or (6.65) (unless we interpret a change from a voiced stop to a nasal as lenition - a change which would involve both demotion of \(\mid C\) and promotion of \(\mid V\) to governing position). Rather, these segments seem to form a leni-
tion hierarchy of their own, in which weakening of a nasal gives a vowel, as in (6.67):

\[
(6.67) \quad \{\mid V \nRightarrow C\} \xrightarrow{\text{vocalisation}} \{\mid V\}
\]

(6.64), (6.65) and (6.67) can be combined to give the following general lenition schema:
(6.68) represents not a single lenition schema, but, rather, a schema with various branches. The main branch involves lenition which originates with voiceless stops. This branch coincides with a secondary branch, involving lenition of the strident sonorants, at various points, but principally at the point where both become (non-nasal) sonorant consonants. Nasal consonants form a separate branch; lenition of a nasal yields a vowel.

6.4.1 Weakening by gesture change

I return now to the other part of Lass's progressive obstruent weakening schema, weakening by 'matrix change', which might be better termed 'gesture change' in the model developed here. This is represented as (6.69):

(6.69) \[ \begin{array}{l}
[\text{oral}] \\
[\text{laryn}] \\
\end{array} \rightarrow \begin{array}{l}
\varnothing \\
\text{[laryn]} \\
\end{array} \rightarrow \begin{array}{l}
\varnothing \\
\end{array} \]
'Dearticulation' of a voiceless fricative to [h], then, is reflected in the dependency model as:

\[
(6.70) \left[ \{\text{artic}\} \right] \rightarrow \left[ \{g\} \right]
\]

while, assuming that the change from a voiceless stop to a glottal stop is a form of weakening, this change will be represented as:

\[
(6.71) \left[ \{\text{artic}\} \right] \rightarrow \left[ \{C\} \right]
\]

As in (6.68), the ultimate 'goal' of weakening of this sort is complete deletion, and Lass argues that representations like these "support the notion of submatrix deletion as a form of lenition, with glottal (i.e. dearticulated) fricatives as the stage before final deletion" (1976:163). The 'defective' nature of [h] and [?] (in that they lack an articulatory gesture) shows why they are the last stage before deletion in obstruent lenition (as opposed to lenition through voicing).

### 6.4.2 Excursus: the nature of lenition

I have noted that lenition processes involve movement along a hierarchy towards zero - the last stage before deletion being a vowel (unless the weakening is by 'gesture change'). In dependency terms, lenition is movement away from |C| towards |V|, with eventual deletion.

There are various other aspects of lenition which I have not considered - some of which I will touch on briefly here. Foley's (1977) 'inertial development principle' states that "weak elements weaken first and most extensively and most preferentially in weak environments" (1977:107). The concept of 'weak environments' is of course traditional - it is well known that certain positions favour lenition. Lass and Anderson (1975:160) show that intervocalic position is "the prime weakening environment", while word-final position is a "variable environment" (1975:166) - on the 'sonority parameter'
it is a strengthening environment (in that obstruents in this position typically devoice), while "from the point of the view of the 'open'/ 'close' dichotomy ... there is a tendency for word-final position to be an opening environment" (in that stops tend to spirantise). Hooper (1976:199) considers syllable-final position to be weak, while syllable-initial position is strong. Escure (1977:58), however, sets up an environmental hierarchy in which the order is final, intervocalic, initial - weakening being most likely to affect clusters in (utterance)-final position, then in intervocalic position, and least likely in initial position. Foley (1977:109) establishes the following "rough classification" of strong and weak environments:

\[(6.72)\]

\[
\begin{array}{ccc}
\text{Strong} & \text{Weak} \\
\text{initial} / \# & \text{final} / \# \\
\text{post-nasal} & \text{intervocalic} / V \\
\text{post-tonic} / \tilde{V} & \text{post-atonic} / \tilde{V}
\end{array}
\]

Given these considerations, it is not surprising that one of the prime environments for deletion of consonants is in final position in the unstressed syllable of a word of two or more syllables. Consider, for example, Dutch <Leiden> /lɛidən/ → /lɛida/; CL <risum> → OFr <rizu> (Pope 1934:98); OE <nemnan> → ME <nempne>, and many other similar examples, in which, in dependency terms, we find the change:

\[(6.73)\]

where C denotes any segment containing a \(|C|\) element, i.e. \{C\}, and S any segment. The reason for the weakness of this position (which appears to be a combination of two of Foley's weak positions (\(/ \# \), and \(\tilde{V} \)) is apparent from the dependency representation of such items. I assume that positional weakness correlates at least to some extent with the degree of dependency of a node in a tree, together with factors such as the degree of convergence of the node in question.
(Anderson and Jones 1974a:10), and possibly its distance (in terms of linear order) from the stressed syllabic. In (6.73) the final C has a degree of convergence of 1, in that it is only connected to one node with a lower dependency degree, i.e. \( V_2 \).

It seems fairly obvious, then, that the propensity of a position to cause lenition is in some way bound to considerations such as the above. But there are still some interesting aspects which have not yet been considered. In the position which I am discussing (the C position in (6.73)), lenition to deletion tends not to involve a \(|V|\) stage; i.e. situations such as that in (6.74) tend not to appear:

\[
(6.74)\]

\[
V_1 \\
\downarrow \\
S \\
\downarrow \\
S \\
\downarrow \\
V_2 \\
\downarrow \\
V_3
\]

I presume that this is due to the fact that such a structure would yield a long vowel (or diphthong) in an unstressed syllable - a situation which is fairly uncommon in the languages of the world. Compare the corresponding position in monosyllables, in which the C segment may indeed weaken to \(|V|\), as in Scots <pull> /pu:l/ → /puː:/

\[
(6.75)\]

\[
V_1 \\
\downarrow \\
S \\
\downarrow \\
V \\
\rightarrow \\
S \\
\downarrow \\
V_2
\]

where this constraint does not hold.

In intervocalic position, deletion seems to be less favoured in weakening processes than in final position. It is common to find semi-vowels in this position - e.g. Dutch <Leiden> /lɛːdɛn/ → /lɛi̯ja/; <rode> 'red' /ɻoːdə/ → /ɻoːja/; <koude> 'cold' /kouðə/ → /kɔwə/ (cf. also /kɔu/, with deletion of both the consonant and the vowel), etc:
In these cases, I presume that a tendency not to produce directly successive syllabics militates against complete deletion in this position (although this is not to say that deletion can never occur in this position).
Chapter 7

The Structure of Sequences

In §4.1 I surveyed briefly the characterisation within the dependency model of phonological sequences such as syllables and words. There we saw (as argued by Anderson and Jones 1974a, 1977) that it seemed appropriate in phonological representations to establish dependency relations between the segments occurring in such units; in particular we saw that, within a syllable, the non-syllabic elements could be said to be dependent on the syllabic, while within sequences longer than the syllable, unstressed syllabic elements were dependent on the stressed syllabic, as in (7.1), the dependency graph for Dutch <boerin> 'farmer's wife':

(7.1)

where the non-syllabics are dependent on the syllabics, while the unstressed syllabic /u/ is dependent on the stressed syllabic /i/. Notice that the final /n/ is not directly dependent on /u/ (because it occurs in a different syllable), but nevertheless has a higher degree of dependency.

It was argued in §4.1 (again following Anderson and Jones) that representations such as (7.1) are appropriate to the extent that we can motivate for any particular phonological unit consisting of more
than one segment a segment which is interpretable as more prominent than the others. Syllabicity appears to be just such a notion, in that the syllabic element is the most prominent element in the syllable; it forms a "unique sonority peak whose identification is available to native speakers" (1974a:9). (I am not concerned here with specifying further the phonetic correlates of syllabicity, an area which has caused a great deal of controversy - see for discussion Ladefoged 1975:217ff; it is sufficient for our purposes that syllabicity correlates with greater prominence, at least perceptually.) Notice that 'degree of prominence' is not an absolute notion; rather, as Anderson and Jones note (1977:116), "syllabicity seems to be an essentially combinatorial notion". The presence of the syllabic as the characteristic element of the syllable, then, allows the syllable to be represented as having a unique determinate governor, to which all non-syllabics are subordinate. In other words, the graph associated with the syllable has a unique centre, or root.

Similarly, stress can also be viewed as a combinatorial relationship, whose function is to pick out one of the syllabics in a polysyllabic string as being more prominent than the other syllabics. Again, the exact phonetic correlates of stress are troublesome to define, but nevertheless the relationship of perceptual prominence holding between stressed and non-stressed syllabics is non-contentious. Thus, the stressed element is viewed as the characteristic element of the phonological word, and we can view the stress rules of, say, Dutch as selecting one of the syllabics occurring in a word as the centre of the graph characterising the word, as in (7.1); i.e. as imposing a unique governor on the graph.

Notice that Anderson and Jones assume syllabicity (universally) and stress (at least in some languages) to be predictable. Thus, lexical entries are dependency free (as far as sequences are concerned) - they consist of simple strings of segments - and dependency structures such as (7.1) are established by "syllabic segment selection" rules (Anderson and Jones 1977:§4.7), and by stress rules such as those in SPE (see Anderson and Jones 1974a for discussion). I shall not be concerned any further with such rules here.
In what follows, it is not my intention to examine these phenomena in any detail, as they are not of direct relevance to my main theme, the establishing of appropriate dependency relations for segmental representations. Rather, the reader is referred to the various sources given above, and in §4.1. However, in the following sections, I want to look at some areas of this treatment which are relevant to segmental considerations. In particular, in §7.2, I shall devote some space to showing that considerations of syllable structure processes lend further support to the representations of the categorial gesture established in chapter 6.

7.1 Syllabification and syllabicity

7.1.1 Syllabification

One of the major problems within phonological theories which assume the existence of the syllable has been the assignment of syllable boundaries, and this has been one of the reasons why many phonologists have rejected the concept of the syllable as a phonological unit. I shall give here only the broadest outline of the overlap theory of syllable boundary placement, associated with Anderson and Jones, and underlying the status of /r/ in (7.1), in which it can be seen that /r/ is simultaneously dependent on two syllabics, /u/ and /l/.

In the overlap theory, intervocalic consonants may, under certain circumstances, be assigned simultaneously to two syllables in pre-stress representations. Thus, the 'syllable bracketing' associated with (7.1) is:

\[(7.2) \ [bu[r]\, in] \]

where the beginning (onset) of the second syllable precedes the end (coda) of the first syllable. Thus /r/ is viewed as forming simultaneously the coda of the first syllable and the onset of the second. Such medial consonants are assigned to both syllables, if they
can, in monosyllabic morphemes, be both syllable-initial and syllable-final in the language in question. Thus, in (7.2), /r/, which can be both syllable-initial and syllable-final in Dutch (e.g. <raar> 'strange'), is assigned to both syllables. Anderson and Jones claim that clusters can be divided amongst syllables according to the same principles, and give the data in (7.3) and (7.4) (1974a:4-5, 1977: 101):

(7.3) medicinal
   algebra
   eloquent

(7.4) utensil
   dependent
   fraternal

(Anderson and Jones are concerned with establishing an interpretation within the overlap theory of Chomsky and Halle's distinction between strong and weak clusters within the English Main Stress Rule. I shall not pursue this here.) In (7.3), we find the division ... a[b]r ... in <algebra>, because while /br/ can form an initial cluster in English, and thus the beginning of syllable 3 precedes /b/, it cannot form a final cluster, and so the end of syllable 2 immediately follows /b/ (which can, on its own, occur syllable-finally). In (7.4), on the other hand, we find ... en[d] ... in <dependent>; /nd/ can be syllable-final, but not syllable-initial, while /d/ alone can be syllable-initial.

Anderson and Jones (1977:104) claim, then, that "the character of medial clusters is governed by the following principles - which are intended to specify the unmarked possibilities for formatives":

(7.5) a. medial clusters are composed of a syllable-final preceding a syllable-initial sequence.
   b. 'precede' includes overlap where required by a maximalist interpretation of the component final and initial.

Thus, the 'maximalist' interpretation states that whenever pre-stress clusters can be both syllable-initial and syllable-final in monosyllables, they will be assigned to both syllables when intervocalic.

Ambisyllabicity in these terms, however, holds only in pre-
stress representations (at least in English). Once stress has applied, the stressed syllable tends to attract consonants to it. Thus, in the English words *prudent* and *prudential*, we might find the following pre-stress syllable bracketing:

\[(7.6) \quad \text{[pru}[d]\text{ant}] \quad \text{[pru}[d]\text{en}[f]\text{al}]\]

where in both cases /d/ is ambisyllabic. However, after stress-assignment, we find the following:

\[(7.7) \quad \text{[pru}[d]\text{ant}] \quad \text{[pru][den][f][al]}\]

In *prudential*, the /d/ no longer forms the coda to the (unstressed) first syllable, but is now uniquely the onset to the second syllable, which is stressed. Unstressed syllables, then, are minimalist, in that any originally ambisyllabic consonant (cluster) is transferred to the following stressed syllable. On the other hand, stressed syllables are maximalist, in that they retain such consonants - in (7.7) we see that the /d/ of *prudent* and the /f/ of *prudential* remain ambisyllabic after stress-assignment. Notice too that the domain within which we find post-stress ambisyllabicity can be interpreted as maximally the foot (cf. the discussion of Selkirk's account in §3.5). Thus in (7.7) *prudent* and *-dential* both form bisyllabic feet.

7.1.2 Syllabicity

I turn now from the margins to the centre of the syllable. The display of segment-types in (6.30) shows segments towards the top left of the diagram to be more |V|-like than segments towards the bottom right:

From such representations, which reflect degree of periodicity in terms of prominence of the |V| component (alone, governing, dependent, absent), the syllabicity hierarchy can be simply read off. (Anderson and Jones 1977:124).

Thus, the most |V|-like segments will form the syllabic peak of the syllable. In most cases this will, of course, be the vowel. However,
in cases where there is no vowel available for syllabic segment selection, it appears that the next most $|V|$-like element will be chosen. If the syllable contains a liquid or a nasal, then, this will be chosen as the syllabic element in preference to less $|V|$-like elements such as fricatives or stops. Thus, items such as the well-known Czech examples /prst/ 'finger' and /brno/ 'Brno' show selection of the liquid as the syllabic element of the first syllable.

Similarly, deletion of a vowel in an unstressed syllable, with the resultant creation of a syllabic consonant, as in English <button> /bʌtn/, <little> /lɪtɪ/ is more likely when the consonant in the second syllable shows prominent $|V|$, i.e. when it is sonorant, than if it is, say, a fricative. Realisations such as <gushes> /gʌʃz/, <plaintiff> /pleɪntɪf/ are less common.

Thus syllabic correlates with high $|V|$-ness. However, there is a further related aspect which must be considered. The internal structure of the syllable also appears to be determined by the relative $|V|$-ness of the segments, and in §7.2 I consider this matter in some detail.

There have, however, been attempts in other models to deal with the problem of syllable structure, and it will be useful to consider these before establishing a dependency interpretation of the phenomenon. These attempts have largely been associated with the kind of hierarchy I discussed in §6.3, and there are two distinct type of hierarchy which have been postulated in characterising syllable structure constraints.

7.2 Syllable structure

7.2.1 Strength hierarchies and syllable structure

The first approach, that of Vennemann (1972) and Hooper (1976, 1977) involves the predicting of syllable structure from the independently motivated strength hierarchies discussed in §6.3. The "partly universal, partly language-specific relational hierarchy of segments"
which Vennemann (1972:7) sets up on these considerations can predict the order of consonants in a syllable. As far as syllabicity is concerned, "the universal aspect...is that certain weak consonants cannot establish for themselves a syllable-initial position in the presence of certain strong consonants" (1972:11).

Similarly, Hooper (1976:199) views the syllable as "a unit whose center is the most vowel-like and whose outer margins are the least vowel-like", and suggests that "it is reasonable to speculate further that any intervening segments will be intermediate between the least and most vowel-like". The universal model of consonant clustering which she establishes (cf. (5.20) above), in which we find this patterning, can be illustrated by the following chart of the possible distribution of consonants in a syllable in Modern Spanish (Hooper 1976:196):

\[
\begin{array}{cccccc}
\$ & C_m & C_n & C_p & V & C_q & C_r & $ \\
\text{m} & = & /f, p, t, k, b, d, g/ \\
\text{n} & = & /r, l/ \\
p, q & = & /j, w/ \\
r & = & /s, m, n, l, r/ \\
\end{array}
\]

($ = \text{syllable boundary}; \text{for convenience, I consider only those consonants in } C_m \text{ position which occur in clusters.})

Clearly, then, the Hooper/Vennemann approach to strength scales outlined in §6.3 can successfully predict syllable structure in, for example, Icelandic or American Spanish. And, indeed, an examination of various other languages will show that such strength scales are adequate in this respect for a large body of languages of the world. There are certainly problems with some languages, some of which I will note briefly in the following section, but it is not my concern to discuss these in any detail. Rather, I want to argue that, although the strength scale may be said to be adequate in the respects discussed above, it suffers from the same kind of difficulties as those considered in §6.4, namely, that the scale appears to have no intrinsic motivation. The position of the elements on the strength scale
appears to be totally arbitrary, while a corresponding scale in terms of dependency representations can be shown to overcome this apparent arbitrariness. I return to this matter in §7.2.3.

7.2.2 Distinctive feature hierarchies and syllable structure

Basbøll (1974a, 1977) establishes a hierarchy, not of segments or segment-types, but of certain distinctive features, which, he claims, will predict the ordering of elements within the syllable in Danish:

(7.9)

In (7.9), the following can be read off:

The syllabic peak together with possible adjacent glides (i.e. [-syllabic, -consonantal] constitute the non-consonantal part of the syllable, often called the 'nucleus'. The non-consonantal part together with possible sonorant consonants constitute the sonorant part of the syllable. The sonorant part together with possible adjacent voiced obstruents constitute the voiced part of the syllable. The voiced part together with possible adjacent voiceless segments constitute the syllable. Thus the following 'implication chains' hold true without exception:

\[
(+\text{syllabic}) \geq (-\text{consonantal}) \geq (+\text{sonorant}) \geq (+\text{voiced}) \text{ and } (-\text{voiced}) \geq (-\text{sonorant}) \geq (+\text{consonantal}) \geq (-\text{syllabic}).
\]

(Basbøll 1974a:101).

For Danish, the following order relations hold:
This syllabic hierarchy, which Basbøll claims might be considered "the maximally 'natural' or 'unmarked' arrangement of distinctive features in the syllable" (1974:106), contains what he calls 'hierarchical' features - a set of features which he distinguishes from other features, not involved in ordering relations, which he calls 'cross-classificatory' (1974a:107). However, to account for the ordering relations of liquids and nasals (liquids being closer to the nucleus of the syllable than nasals in Danish), Basbøll is forced to characterise [continuant] as a 'semi-hierarchical' feature, which is hierarchical only within the sonorant part of the syllable, as in (7.11):

Basbøll claims the syllable hierarchy as a candidate for a universal model to predict ordering within the syllable, and indeed it...
appears to be adequate to account for a range of languages other than Danish - e.g. Swedish (see the phonotactic constraints established by Sigurd 1965), Dutch (Cohen et al 1961), Italian (Basbøll 1974b), and American Spanish (Hooper 1976). Notice that in languages other than Danish, some of the order-classes which Basbøll's model can predict may be redundant - e.g. in Swedish (Sigurd 1965:81), the hierarchical feature [consonantal] appears to be redundant in syllable-final position. Sigurd sets up the following 'final order classes' for post-vocalic clusters in Swedish:

\[
\begin{align*}
&\text{V} \quad \text{C} \\
&\text{L+N} \\
&\text{L} \\
&\text{r} \quad \text{m} \quad \text{v} \\
&\text{l} \quad \text{n} \quad \text{j} \\
&\text{i} \quad \text{g} \quad \text{k} \\
&\text{b} \quad \text{f} \quad \text{p} \\
\end{align*}
\]

(V = voiced, VL = voiceless, C = continuant, S = stop, N = nasal, O = oral, F = fricatives, L = liquid. Notice that Sigurd does not work within an explicit feature framework.) Sigurd extracts the following generalisations about the ordering relations of consonants in syllable-final position in Swedish:

\[
\begin{align*}
1. \text{voiced before voiceless} \\
2. \text{continuants before stops} \\
3. \text{liquids and nasals before fricatives} \\
4. \text{liquids before nasals.}
\end{align*}
\]

Clearly, Basbøll's syllabic hierarchy is adequate to account for the ordering relations holding in (7.12) and (7.13). The hierarchical feature [consonantal], then, is redundant in syllable-final position in Swedish, in that Swedish shows no [-syllabic, -consonantal] segments postvocally. However:

The fact that some of the 'boxes' have no descriptive justification in a given language does not in itself prove
that the model is not universal. As long as a language ... does not offer counter-examples to the orderings predicted by the general model, then it is in accordance with the model in the sense that a strict subset of the hierarchical features in the same order will be a relevant model for its syllabic structure. ... Each language takes all of these features or any subset of them in the order given to form its syllabic hierarchy. (1974a:106-107).

For Swedish, then, the following 'linearisation' of the syllabic hierarchy is relevant (notice that (7.14) contains also the linearisation of syllable-initial consonant clusters - see Sigurd 1965:59-60):

(7.14) is appropriate if /j/ is sonorant in prevocalic position (e.g. /mj-/ , /nj-/ , etc.), but obstruent in postvocalic position (/-jd/, /-mj/, /-nj/, etc.). /v/ in syllable-initial position does not occur after sonorants, as we would expect. In Swedish, the feature [continuant] again plays a semi-hierarchical role.

In Norwegian, however, certain problems arise. Vogt's (1942) study of the monosyllable in Norwegian shows that only two order classes seem to be involved in syllable-initial position:

In (7.15) the second position is not the 'voiced' part of the syllable, as /bdg/ occur in first position, nor is it the 'sonorant' part, as /vj/ are not sonorant. The only characterisation in terms of distinctive features appears to be:

(7.16)
which is inadequate on grounds of its complexity and unnaturalness. In addition, it makes use of the feature [continuant] - a feature which is only semi-hierarchical in syllable-final position in Norwegian, where we find the following:

\[(7.17) \begin{array}{c|c|c}
+\text{cons} & -\text{son} & -\text{voi} \\
+\text{son} & +\text{voi} & \\
\end{array} \]

\[
\begin{array}{cccc}
\text{r l} & \text{J} & \text{p t k} \\
\text{m n q} & \text{b d g} & \text{f s} \\
\end{array}
\]

with [+cont] again predicting the order of liquids and nasals. Notice that the characterisation in (7.16) does not violate the syllabic hierarchy set up by Basbøll - there are no ordering relations which cannot be predicted by the hierarchy. Rather, the set of hierarchical features given cannot adequately characterise the members of the order classes.

Turning now to a non-Germanic language, Italian, Basbøll (1974b: 34-35) notes that no more than one consonant may occur syllable-finally. For syllable-initial position, Basbøll gives the following formula:

\[(7.18) \# ( (s) \{ \frac{C}{0, L} \} ) V \]

Les parenthèses signifient une option, les accolades une alternative. C ("consonne") signifie n'importe quelle consonne. O ("obstruente")... signifie une des consonnes /ptkbdgf/... L ("liquide") signifie... /lr(\lambda)/.

The order of the items in (7.18) can again be predicted by Basbøll's hierarchy - and again a subset only of the hierarchical features will be required.

Although Basbøll claims that the hierarchy displays at least a universal tendency, he himself points out that clusters like [mgl-,
1g-] in Russian violate the model:

But notice that [the model] will apply if the feature [sonorant] is removed... it is not possible to reverse any of the hierarchical features if the model is still to be consistent with the data. I.e., it is not true in Russian that sonorants cannot be nearer to the syllabic peak than voiced obstruents (e.g. [gl-, br-]). (1974a:107).
While Basboll's theory has the advantage of imposing some structure on distinctive feature matrices, in that he establishes subclasses of features (hierarchical vs. cross-classificatory), the choice of the particular features involved appears to be fortuitous. Notice, for example, the treatment of [continuant] as a semi-hierarchical feature. In fact, although Basboll treats [continuant] as hierarchical only within the sonorant part of the syllable, it can plausibly be argued that it is also hierarchical within the non-sonorant part. Basboll's reason for not treating it as such is that it is not possible to predict the ordering relations of stops and fricatives. However, it seems that in many languages, stops are always further away from the syllabic peak than fricatives, provided that we leave /s/ out of consideration. /s/ can occur typically before stops in initial position, and after stops in final position. We do not, in general, find syllable-initial clusters such as */ɔg-/, */xp-/, or syllable-final clusters like */-tx/, */-bv/, while clusters involving /s/ are quite common - /st-/, /spr-/, /-ps/, /-rks/, etc. (This, of course, is not to deny that clusters involving other fricatives occur, but they are relatively rare; the cluster /ft-/, for example, occurs in Russian /ftor/ 'fluorine', and Modern Greek /ftero/ 'wing'.) In §7.4.6 I offer a detailed discussion of clusters involving /s/, and their characterisation in models of phonological representation. If we accept that such clusters are in some sense 'irregular', we could argue that for regular clusters [continuant] is hierarchical within both the sonorant and the non-sonorant parts of the syllable, as in (7.19):
In this interpretation, [continuant] is still not a fully hierarchical feature, but the effect of the display in (7.19) is rather that within both the sonorant and non-sonorant parts of the syllable, the order of continuant and non-continuant segments can be predicted. This would enable us to account for clusters such as Swedish final /-řt/, /-lvd/ and initial /tv-, and Dutch final /-xt/, /-ft/, /-rxt/, /-rnst/, etc. It does not provide any explanation of why /s/ should behave in a consistently idiosyncratic way across a wide range of languages, but does show that only one segment is involved in this idiosyncracy, rather than a whole class of segments. But is is clear that [continuant] is still unlike the other hierarchical features in that it occurs in two places in the hierarchy, and can only predict ordering relations within parts of the syllable. There appears to be nothing inherent to the particular features involved which suggests that, for example, [sonorant] should be hierarchical, [continuant] semi-hierarchical, and various other features cross-classificatory (cf. the observations in §§6.3 and 6.4).

Finally, observe that the kind of criticism offered in §7.2.1 with respect to the Hooper/Vennemann model is equally applicable to the Basbøll distinctive feature hierarchy. Specifically, the need for a hierarchy of this sort arises again from the inadequacy of the system of representation, in that the patterning of segments which Hooper/Vennemann and Basbøll attempt to characterise is not reflected in the representations of these segments.

7.2.3 Dependency phonology and syllable structure

Within dependency phonology, the difficulties arising from the need for the sort of predictive hierarchies discussed in the previous two sections does not arise, because the representations are such that externally imposed hierarchies of this kind are redundant, as shown in §6.3. Applying the representations of the categorial gesture established in §6.1 to the Danish data discussed by Basbøll, we find:
The further away from the centre of the syllable that we go, the less prominent becomes the \(|V|\)-component, and the more prominent the \(|C|\)-component (Anderson and Jones 1977:124). That is, segments nearer the nucleus are more \(V\)-like than segments further away from the nucleus. (In (7.20) and below, I use the notation \(X;Y\) to denote that \(X\) unilaterally governs \(Y\).)

This simple principle, then, accounts for the same set of data as Basbøll's distinctive feature hierarchy - that is, ordering relations can be predicted from the phonological representations themselves, and need not be determined by an externally imposed hierarchy. Similarly, there is no need to make syllabicity dependent on a strength hierarchy such as that of Hooper/Vennemann.

We can establish the appropriate dependency trees for any of the Danish items whose syllable structure can be predicted by Basbøll:

(7.21) \[
\begin{align*}
&V \\
&V,C;V \\
&C \\
&V,C;V
\end{align*}
\]

dværg  /dve\j\'y/ 

(7.22) \[
\begin{align*}
&V \\
&V,V,C \\
&C \\
&V,C \\
&C
\end{align*}
\]

plankt  /plan\'g/
The internal structure of the syllable correlates with such a hierarchy [of syllabicity], so that segments with a high $|V|$ component tend to come closer to the syllabic than low $|V|$ elements. It is likely that this too is appropriately represented in terms of dependency: in general, then, distance from the syllabic correlates with greater subordination. (Anderson and Jones 1977:124).

Thus, to return to the data considered in (7.3) and (7.4), we have the following representation for `<dependent>`:

(7.23)

```
```

where (in the medial cluster between syllables 2 and 3), /d/ is subordinate to the governors of both syllables (cf. §7.1.1), while /n/ is subordinate only to the governor of the second syllable. Observe, too, that /p/ is dependent only on the governor of the second syllable. As this is a post-stress representation, ambisyllabicity holds only within the foot. Similarly, `<eloquent>` will have the representation in (7.24):

(7.24)

```
```

where /k/ is dependent on /w/ (which I treat as a sonorant consonant -
A word like Danish <skœlmsk> /sge1'msg/, containing /s/ preceding a stop in syllable-initial position, will have a representation like (7.25):

\[
(7.25) \quad \begin{array}{c}
V \\
\downarrow \\
V;V,C \\
\downarrow \\
C \\
\end{array}
\]

where prevocalic /g/ is dependent on /s/ because of the relative prominence of \(|V|\) in each sub-tree. In all 'regular' cases, however (i.e. those in which the syllable structure can be predicted by Basboll's hierarchy), distance from the syllabic correlates with a greater degree of subordination. Precedence and dependency, then, are not independent. Thus, the exceptional behaviour of /s/ with respect to ordering within the syllable is reflected by the structure in (7.25), in which the normal correlation between linear and hierarchical distance from the syllabic is absent. I return to a detailed discussion of the characterisation of such abnormal clusters in §7.4.6.

The dependency model, then, can predict any order relations which can be predicted by Basboll's hierarchy, by virtue of the simple principle that more \(|V|\)-like segments will occur nearer to the nucleus than less \(|V|\)-like segments, without the need for a hierarchy external to the relations themselves. This does not mean, of course, that the dependency model (or indeed the Basboll hierarchy) will predict the members of each order class, or indeed the number of order classes, in a particular language - this is a linguistic variable. We should not, then, be surprised that languages like Norwegian (see (7.15) and (7.16)) do not show order classes corresponding to Basboll's notion of the 'voiced' or 'sonorant' part of the syllable. The order classes
in (7.15) can be represented as (7.26):

\[
(7.26) \quad \begin{array}{c}
\{|c|\} \\
\{|c;v|\} \\
\{|v;c|\}
\end{array} \rightarrow \begin{array}{c}
\{|v;v,c|\} \\
\{|v,c;v|\} \\
\{|v;c|\}
\end{array}
\]

The apparent unnaturalness of (7.16) is shown to be a result of the distinctive feature framework - in (7.26) we see that the usual pattern operates, in that the first box contains segments with less prominent \(|V|\) than the second.

7.2.4 Constituents within the syllable

In §3.5 we saw that, within the syllable, Selkirk distinguishes the rhyme (i.e. the nucleus and the coda) from the onset. The notions of the rhyme and the nucleus forming constituents within the syllable can be given a formal interpretation within the type of dependency structure proposed here. Consider first the structure for \(<\text{end}>\), where there is no onset, and the nucleus consists of only one segment:

\[
(7.27) \quad \begin{array}{c}
\varepsilon \\
\n \\
\d
\end{array}
\]

In a monosyllable containing a long vowel or diphthong, such as RP \(<\text{old}>\), we have the following:

\[
(7.28) \quad \begin{array}{c}
\varepsilon \\
\circ \\
\_ \\
\d
\end{array}
\]
It is clear that in (7.27) and (7.28) the nucleus is not formally distinct from the coda. This might be remedied by adopting a representation such as (7.29):

\[(7.29)\]

where the nucleus is the constituent deriving from the lower node, and the rhyme the constituent deriving from the upper node dominating /ə/... However, such a formulation fails to allow for the fact that sequences of short vowel + sonorant consonant + sonorant consonant and long vowel (diphthong) + sonorant consonant frequently form a natural class (see, for example, chapter 11 below). That is, the two representations in (7.30) and (7.31) (respectively Dutch <urn> 'urn' and <oor> 'ear') are formally different:

\[(7.30)\] \hspace{1cm} \[(7.31)\]

In this treatment, then, the status of these two forms appears to be different, whereas they behave in the same way with respect to various processes in Dutch phonology. In order to represent this, (7.32) - (7.34) seem more appropriate characterisations:
where the rhyme is constituted by all nodes subordinate to the lower syllabic node (and the syllabic itself); the nucleus by all nodes uniquely dependent on the lower syllabic node (and the syllabic); and the coda by all nodes that are non-nuclear, and subordinate to both the upper and lower syllabic nodes.

Similarly, the onset of the syllable may be viewed as being subordinate to a still higher node, as in (7.35), the tree for Dutch <vreemd> 'strange':

(7.35)
If such notions are formally required, these representations provide a way of distinguishing the various categories. However, in what follows, I shall in the main confine myself to the more simple representations discussed in §7.2.3.

7.3 Stress within the word

I have already noted that within dependency phonology stress can be viewed as a combinatorial notion, the function of the stress rules in a language in which stress is predictable being to select the stressed syllabic as the governor of the phonological word in question.

However, it is clearly not the case that all words necessarily contain just one syllabic element which is more stressed than the rest. Rather, a word may contain a syllabic which bears secondary stress, as well as one which bears primary stress, and others which are unstressed. This state of affairs is characterised in $\text{Spe}$ by the use of what is effectively a scalar (non-lexical) feature of stress. Thus, a word such as Dutch <wandeling> 'walk', in which the first syllable has primary stress, and in which, according to native speakers, the syllabic element of the third syllable is more stressed than that of the second, the stress pattern might be informally represented by Chomsky and Halle as /wand3lir/.

This situation may be represented in dependency phonology as involving an extra degree of dependency. Thus, the stress rules select /α/ as the overall governor of the word (i.e. as having a dependency degree of 0 - DDO), and assign secondary stress to /ɪ/ (DD1), and tertiary stress to /ə/ (DD2). Thus /ə/ is dependent on both /α/ and /ɪ/, while /ɪ/ is dependent on /α/, to give (7.36):
The interpretation of stress in this fashion makes it rather
difficult to utilise a formal possibility available within the SPE
model, and utilised by Haverkamp-Lubbers and Kooij (1971) in their
account of the phonological behaviour of the diminutive in Dutch—a
possibility which, however, seems in this case to be undesirable.
Haverkamp-Lubbers and Kooij note that a word such as <leerling> 'pu-
pil' takes a diminutive in /atjə/, while <paling> 'eel' takes a dimi-
nutive in /kələ/, and suggest that the different behaviour is determ-
ined by a difference in stress pattern, the patterns being respective-
ly /leérɪŋ/ and /pælɪŋ/. Thus, <leerling> has tertiary stress on the
second syllable, while the second syllable of <paling> is unstressed.
The implication of this treatment is, of course, that the second syl-
lable of <paling> is less stressed than that of <leerling>. However,
I have been unable to find any native speaker support for this claim.
The implication of Haverkamp-Lubbers and Kooij's claim is that stress
is an absolute notion, and that degrees of stress can be compared di-
rectly between different words; however, it seems that such compari-
sions should be formally complex to express, if they are available at
all.

In chapter 11 I return to a fuller discussion of this problem
with respect to the Dutch diminutive, but it is useful to notice at
this point that the dependency representation of stress developed so
far precludes the kind of treatment proposed by Haverkamp-Lubbers and
Kooij. In the dependency model, the relationship between the vowels
of the first and second syllables is the same for both categories of
vowels. Specifically, the second vowel is dependent on the first:
Because the relationship between \( V_1 \) and \( V_2 \) is relative (i.e. \( V_1 \) is 'more' prominent than \( V_2 \)), rather than absolute, as in the SPE model (i.e. \( V_1 \) has \([n]\) stress, and \( V_2 \) \([n+m]\) stress), where \( m \) can differ according to the nature of \( V_1 \) and \( V_2 \), it is formally impossible within the model developed so far for a distinction to be made between different stress patterns in this way.

However, if we were to accept that this distinction is nevertheless necessary; i.e. if we accept Haverkamp-Lubbers and Kooij's claims about the Dutch forms, or Schane's (1979:496) claim that English \(<\text{permit}>\) and \(<\text{hermit}>\) have different stress patterns (which is not the case in my speech), then we can incorporate a formal characterisation of this in the dependency trees. Something like (7.38) seems necessary:

\[
(7.37) \quad \begin{array}{c}
0 \quad 1 \\
\downarrow \quad \downarrow \\
V_1 \quad V_2
\end{array}
\]

\[
(7.38) \quad \begin{array}{c}
0 \quad 1 \\
\downarrow \quad \downarrow \\
V_1 \quad \text{per - mit}
\end{array} \quad \text{vs.} \quad \begin{array}{c}
0 \quad 2 \\
\downarrow \quad \downarrow \\
V_1 \quad \text{her - mit}
\end{array}
\]

in which an extra degree of dependency is introduced. This distinction might seem more appropriate for a pair such as \(<\text{gymnast}>\) and \(<\text{modest}>\), where the alleged stress difference correlates with the absence vs. presence of vowel reduction; notice, however, that this may be due to other factors - \(<\text{gymnast}>\) shows a structure in which there is no syllable overlap, as opposed to \(<\text{modest}>\):
7.4 Unit vs. cluster in phonological representations

The remainder of this chapter will be devoted to a detailed discussion of an area which is on the borderline between segmental and suprasegmental phonology, and hence is more directly of relevance to the main topic of this thesis - the representation of vocalic 'units' such as diphthongs and long vowels, and, in particular, of certain consonantal 'units' such as geminates, affricates, and prenasalised stops, and of consonant clusters involving /s/. The problem which I will be addressing is whether such items should be given a treatment in which they are interpreted as a single segment, or whether they should be analysed as a sequence of two segments, or whether they should be viewed as single segments with some kind of internal sequential structure. The problem of whether to give a monosegmental or bisegmental interpretation of items such as these has been discussed in the literature for a very long time - see, for example, Trubetzkoy (1939), Martinet (1949), Pike (1947). These linguists provide arguments for setting up various principles to determine whether to analyse a particular phonetic sequence as one phonological unit or two; however, I shall here consider these arguments only insofar as they are relevant to the particular areas mentioned above.

7.4.1 Diphthongs and long vowels

Diphthongs, as the name might suggest, have often been interpreted phonologically as being made up of a sequence of two vowels, i.e. they have been interpreted as bimoric. Traditional notational systems such as the transcription system of the IPA (1949), as used by Gimson (1970) to characterise the phonemic system of RP, represent diphthongs in this way, e.g. /iə/, /ɛə/, /aɪ/, /æə/, etc., where the first symbol denotes the 'starting-point' of the diphthong, and the second symbol the 'end-point'. Long vowels, on the other hand, are not necessarily shown to be bimoric - rather they are characterised by Gimson by means
The characterisation of such units within notational systems has given rise to a great deal of discussion, and Lass (1976: ch. 1), in the course of setting up a characterisation which is basic to that used within dependency phonology (cf. Anderson and Jones 1977: 169, and below), offers a comprehensive account and critique of the SPE treatment of this area.

Lass notices that:

English (phonetic) vowel systems can have either two or three contrasting nuclear types: short monophthongs vs. diphthongs (New York City), or short monophthongs vs. long monophthongs vs. diphthongs (RP, Bridlington). I know of none with only short and long monophthongs. (1976: 4).

The various phonetic vowel systems are presented in (7.40):

(7.40)  

<table>
<thead>
<tr>
<th>(A)</th>
<th></th>
<th>(B)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>NYC</td>
<td>RP</td>
<td>Br</td>
<td>NYC</td>
</tr>
<tr>
<td>bit</td>
<td>ɨ</td>
<td>ɨ</td>
<td>meet</td>
</tr>
<tr>
<td>bet</td>
<td>ɛ</td>
<td>ɛ</td>
<td>mate</td>
</tr>
<tr>
<td>bat</td>
<td>a</td>
<td>a</td>
<td>boot</td>
</tr>
<tr>
<td>put</td>
<td>ʊ</td>
<td>ʊ</td>
<td>boat</td>
</tr>
<tr>
<td>pot</td>
<td>ɔ</td>
<td>ɔ</td>
<td>bought</td>
</tr>
<tr>
<td>but</td>
<td>ə</td>
<td>ʌ</td>
<td>father</td>
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</tbody>
</table>

where NYC shows only diphthongs in (B), while RP and Br show both long vowels and diphthongs.

However, although dialects like RP show a three-way phonetic distinction, Lass argues that there is evidence to suggest that at the phonological level there is a dichotomy "in which all members of (B), regardless of their surface realizations, form a set opposed as a whole to (A)" (1976: 6). The evidence is of two kinds: distributional, in that members of (B) "can appear in word-final position under
accent, while those of (A) are excluded: thus bee, bay, boo, boy, etc. but *[b\text{\textumlaut}i], *[b\text{\textumlaut}e], *[b\text{\textumlaut}æ], *[b\text{\textumlaut}o], and so on", and morphophonemic, in that "English shows a large number of fairly regular alternation sets, in which one term is a member of (A) and the other of (B); but where monophthongal and diphthongal members of (B) are not distinguished from each other in any way", as in (7.41):

<table>
<thead>
<tr>
<th></th>
<th>NYC</th>
<th>RP</th>
<th>Br</th>
<th></th>
<th>NYC</th>
<th>RP</th>
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<tbody>
<tr>
<td>divinity</td>
<td>ë</td>
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<td>divine</td>
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<tr>
<td>serenity</td>
<td>ë</td>
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<td>serene</td>
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<td>ë</td>
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<tr>
<td>insanity</td>
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<td>ë</td>
<td>ë</td>
<td>insane</td>
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<tr>
<td>conical</td>
<td>ë</td>
<td>ë</td>
<td>ë</td>
<td>cone</td>
<td>œ</td>
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<td>œ</td>
</tr>
</tbody>
</table>

Lass further discusses two analyses of the English vowel system which incorporate this dichotomy assumption, that of Trager and Smith (1951), and that in sPE, which is in some respects based on that of Trager and Smith. The essence of the Trager and Smith proposal is that "all vocalic nuclei in English are phonologically either 'simple' or 'complex'. The simple nuclei consist of vowels alone, and the complex ones are sequences of vowel plus 'glide' or 'semivowel'." (Lass 1976:7). There are three such glides: a fronting glide /y/, which is realised phonetically as a non-syllabic vowel in the [i–e] range, a backing glide /w/, realised as a vowel in the [u–o] range, and a centring glide /h/, realised as something like [æ], or after non-high vowels, as length. This analysis gives the following phonemicisation of the New York vowel system (from Lass 1976:8):

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<tbody>
<tr>
<td>bit</td>
<td>l</td>
<td>meet</td>
<td>ly</td>
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<tr>
<td>bet</td>
<td>e</td>
<td>mate</td>
<td>ey</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>bat</td>
<td>æ</td>
<td>boot</td>
<td>uw</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>put</td>
<td>u</td>
<td>boat</td>
<td>æw</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pot</td>
<td>æ</td>
<td>bought</td>
<td>oh</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>but</td>
<td>æ</td>
<td>father</td>
<td>ah</td>
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<td>suit</td>
<td>uw</td>
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<td>bite</td>
<td>ay</td>
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<tr>
<td></td>
<td></td>
<td>doubt</td>
<td>æw</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>quoit</td>
<td>œy</td>
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</tr>
</tbody>
</table>
The *SPE* analysis also utilises the dichotomy between (A) and (B). Vowels from (B) are characterised (phonologically) as [+tense], and, as such, are distinguished from the [-tense] vowels in (A). Vowels which are [+tense]:

are produced with a deliberate, accurate, maximally distinct gesture that involves considerable muscular effort; ... the period during which the articulatory organs maintain the configuration is relatively long. Tense ... vowels are executed with a greater deviation from the neutral or rest position of the vocal tract than are the [lax vowels]. (*SPE:* 324).

Thus, phonologically, it appears that the simple/complex distinction of Trager and Smith is not maintained in the *SPE* analysis. However, in the course of the derivation of the vowels in at least some of set (B), a homorganic 'glide' [y] or [w] is inserted, to give (7.43) (from Lass 1976:11):

(7.43) Surface | Lexical
--- | ---
meet | Ty | ð
mate | ðy | ð
boat | ðw | ð
bite | ðy | ð
quoit | ðy | ð

(where the qualitative difference between surface and lexical forms is due to the application of Chomsky and Halle's synchronic vowel shift rules; notice that the macron over a vowel denotes that it is [+tense]).

However, as Lass (1976:§1.4) points out, there is no evidence to support the claim that 'tense vowels' in English have such an off-glide (a sound which is, notice, closer than Cardinal Vowels 1 and 8 respectively). Rather, the second element of English closing diphthongs is always vocalic, and is frequently even a mid vowel:

It is instructive that Trager and Smith, whose study of American English is based on superbly detailed and sophisticated phonetic observations, found no postvocalic 'glides' closer than [ɪ u], and in general found them more like [ɪ o] or even [e o]. (Lass 1976:16-17).
Similarly, Lass notices a "troublesome circularity" in Chomsky and Halle's account. All vowels which appear phonetically with the off-glide have at some stage in their derivation been [+tense]. Further, Lass argues, the nucleus represented by Chomsky and Halle as [Ty] in the SPE dialect never has a first element [T], but rather [i]. Thus, Lass claims, "the macron over the [T] must be a purely phonological - not phonetic - 'observation'" (1976:14-15). The feature [tense] for such vowels is "a purely abstract 'diacritical' operator at a prephonetic level, which is projected onto phonetic representations by hindsight".

Lass proposes a different solution; that the vowels of set (B) are bimoric, while the vowels of set (A) contain just one mora of length. In other words, long vowels and diphthongs have the structure /VV/, as opposed to short vowels which are /V/. Such an account captures also the simple/complex distinction of Trager and Smith. Long vowels and diphthongs are distinguished from each other by the "identity or nonidentity of nuclear constituents. Thus long vowels are /V_1V_1/, and diphthongs are /V_1V_2/, where 'i', 'j' are any potentially distinctive feature specifications" (1976:22). Lass shows that such an account does not raise any problems in phonological terms, as well as being phonetically accurate. He presents a survey of the most important types of rules affecting bimoric nuclei, which I reproduce informally here.

"Raising, lowering, fronting, retraction of long vowels" involves a change from V_1V_1 to V_jV_j. "Diphthongisation of long vowels" involves V_jV_1 becoming V_1V_j (or V_jV_1). "Monophthongisation of diphthongs" involves V_1V_j becoming V_1V_1 (or V_jV_j). "Lengthening of short vowels" involves V_i becoming V_iV_i. "Diphthongisation of short vowels" involves V_i becoming V_iV_j, and "shortening of long vowels" involves V_jV_i becoming V_i. Thus all common processes can be readily represented in the notation, which, as Lass himself notices, has been proposed before.

The proposal that the vowels of set (B) be treated as bimoric has been incorporated into dependency phonology (see Anderson and
Jones 1977). As in the Lass model, then, long vowels and diphthongs are interpreted in the categorial gesture as successive occurrences of a |V| component. However, it is appropriate to investigate the possibility of dependency relations holding between the two |V|s - that is, in the representation of long vowels and diphthongs, should either element govern the other?

I begin by looking at diphthongs. Diphthongs are traditionally divided into two types - falling, where the first element is more prominent, and rising, where the second element is more prominent. The prominence relationship between the two elements can be given a natural interpretation within dependency phonology (cf. Anderson and Jones 1977:69). For falling diphthongs, the second element is dependent on the first, as in (7.44), while for rising diphthongs, the first element is dependent on the second, as in (7.45):

\[
\begin{array}{c}
(7.44) \quad V_i \\
\quad \downarrow \ 
\end{array}
\begin{array}{c}
(7.45) \quad V_j \\
\quad \downarrow \ 
\end{array}
\]

Thus the representations in (7.44) and (7.45) appropriately reflect the relative prominence of the two elements of the diphthong - a structural property which is absent in the model used by Lass. Notice that Donegan (1978:107-108) suggests:

In rising diphthongs, the first of the two vocalic elements is the non-syllabic and the second is syllabic - VV. Such glide-vowel sequences are in some ways more like consonant-vowel sequences than...vowel-vowel sequences. In rising diphthongs, the non-syllabic counts as part of the syllable-onset.

An interpretation of this sort suggests a representation like (7.46) for these sequences, rather than that in (7.45):

\[
\begin{array}{c}
(7.46) \quad V \\
\quad \downarrow \ 
\end{array}
\]

Notice, too, that the first element of a rising diphthong is always at least as high as the second, and is often very close; hence, the
representation of the first element in (7.46) as a semi-vowel seems appropriate.

Anderson and Jones treat long vowels in a similar fashion to falling diphthongs, as in (7.47):

\[(7.47) \quad V_i \quad V_i\]

i.e. a representation in which the first \(V\) governs the second (identical) \(V\).

This interpretation allows the vowels of group (B) to be characterised as a natural class (containing the structure \(|V| \neq |V|\)) as opposed to the short vowels of group (A) (containing only \(|V|\)). Thus, in the data considered by Lass, the Bridlington realisations of <bit>, <boat>, and <bite> will have the categorial representations in (7.48):

\[(7.48) \quad (A) \quad V \quad C; V \quad C; V \quad c_{\text{bit}} \quad (B) \quad V_i \quad v \quad V_i \quad C; V \quad C; V \quad v \quad c_{\text{boat}} \quad V_i \quad v \quad V_j \quad C; V \quad C; V \quad v \quad c_{\text{bite}}\]

This characterisation of long vowels proposed by Anderson and Jones differs from that of Ó Dochartaigh (ms a), who suggests that long vowels have the structure in (7.49):

\[(7.49) \quad V \quad V\]
in which "we have two elements in a dependency relationship to a governing node where, although one element precedes the other, neither is selected as the dominating one". This characterisation, however, involves the creation of a structure which has the properties of a constituency, rather than a dependency, tree. Specifically, the upper node does not dominate any (surface) element. Notice, too, that with such a configuration it becomes very difficult to characterise the natural class formed by sequences such as those in (7.30) and (7.31).

I return in chapter 8 to an account of the representation of diphthongs in the articulatory gesture.

7.4.2 Monosegmental and bisegmental analyses of consonant sequences

I turn now from vowels to consonants, and to an area which is related to the discussion of the previous section. There are a number of consonantal phenomena whose representation in phonological models has given rise to controversy, controversy which is due to disagreement as to whether they should be characterised as single segments, or as sequences of segments, or as something 'in between'. Much of the disagreement has centred around the status of affricates, which, at least phonetically, appear to involve two distinct phases - a closure phase, and some kind of friction phase - but various other phenomena which also appear to involve some kind of change in the course of the production of a consonant are relevant here. For example, prenasalised and postnasalised consonants involve phonetically a change from velic opening to velic closure (or vice versa) in the course of the production of something which appears to be of normal segment length, while preaspiration seems to have a similar status. We shall also see that there is another area relevant to this discussion, which is, however, traditionally interpreted as involving simply two successive segments. This is the representation of clusters of /s/ followed by a stop, which, I shall argue, show certain of the properties of the items mentioned above.

There have been various proposals to characterise such items as 'compound phonological segments' (Hoard 1967, 1978, St Clair 1972,
Hoard claims that the (segmental) SPE feature [delayed release] (which distinguishes plosives from affricates): covers up the difference between a simple and a complex segment. By a complex segment I mean one with intrinsic sequential properties. ... Affricates are complex segments by this definition; it is reasonably clear that the first part of affricates is [-continuant], the second part [+continuant].

Thus, the affricate /tʃ/ in English is represented as (7.50), while the (bisegmental) sequence /ts/ has the representation in (7.51):

(7.50) \[
\begin{array}{c}
C \\
+\text{coronal} \\
+\text{anterior} \\
-\text{continuant} \\
-\text{voice} \\
\text{etc.}
\end{array}
\]

(7.51) \[
\begin{array}{c}
C \\
+\text{coronal} \\
+\text{anterior} \\
-\text{continuant} \\
-\text{voice} \\
\text{etc.}
\end{array}
\]

St Clair explicitly revives Bloomfield's (1933) notion of the compound phoneme, by which "he meant that two simple phonemes act as a unit". Thus Bloomfield proposed that a voiceless alveopalatal affricate [tʃ] acts as a single unit, but is composed of two simple phonemes - a voiceless alveolar stop [t], and a voiceless palatal sibilant [ʃ]. St Clair suggests the incorporation of a "compound phonological segment convention" in the framework, a convention which is reproduced as (7.52):

(7.52) \[
\text{Convention (7.52) applies, for example, in the case of affricates. Thus, the difference between}<\text{Why choose?}>[\text{waytʃuz}] \text{and}<\text{white shoes}>[\text{waytʃuz}] \text{is characterised by (7.53):}
\]

(7.53) \[
\text{AFFRICATE CONTRACTION}
\]

\[
[t][ʃ] \rightarrow [t][ʃ] / * \quad #
\]
where the environment, employing Bach's (1968) mirror image convention, is to be read as 'before and after a word boundary'. Thus the status of [t$\ddot{s}$] in <choose> as a unit cluster is reflected by the convention. "Furthermore [the affricates'] inner structures are revealed when this convention is employed" (1972:125).

Similarly, Campbell (1974:59-60) proposes that affricates should be treated as "complex units or complex segments...[and] written with more than one column of features, but...interpreted as a single unit", as in (7.54):

(7.54) \[
\begin{array}{c}
\text{-anterior} \\
\text{+coronal} \\
\text{+strident} \\
\text{-continuant}
\end{array}
\]

where (7.54) represents /$\varsigma$/ (or /t$\ddot{s}$/).

S. Anderson (1974,1976) is concerned with the characterisation of prenasalised stops:

in a variety of languages of Africa, South America, South Asia, New Guinea, and various areas of the Pacific, elements transcribed as [m$b$ n$d$ $n$g] etc. clearly behave as single units. (1976:331).

Further, he notes the existence of:

another type, referred to as 'postnasalized stops' or 'pre-stopped nasals'. Such sounds, transcribed [p$m$ t$n$ $n$] etc., are found in a number of South American languages, in some Indonesian languages, in some of the languages of New Caledonia, in some of the phonologically aberrant languages of Australia, and perhaps elsewhere. Like the prenasalized stops, they have the distributional and phonological properties of single segments.

He notes that these two types, and ordinary nasals, differ from each other only in relative timing, and for this reason "any feature which purports to characterise the entire segment uniformly, like [continuant] or [sonorant], is apparently destined to fail". It is this that leads him to propose that pre- and post-nasalised consonants are complex segments, which he characterises as (7.55) (1976:338):
or, alternatively, as (7.56):

(7.56) \[
\begin{array}{c|ccc}
\text{syl} & + & - & - \\
\text{cons} & - & + & + \\
\text{nasal} & - & + & + \\
\text{high} & - & - & - \\
\end{array}
\]

(7.56), he claims, is more appropriate, in that it reflects the fact that nasality may have as its domain more than just a single segment, and may 'spread' into adjacent segments (cf. the autosegmental theory discussed in chapter 3).

Similar proposals for the introduction of complex segments into the system of phonological representation have been made elsewhere, the first apparently by Hoard (1967). S. Anderson (1978) and Hoard (1978) offer the complex segment analysis with respect to other phenomena. Anderson (1978:54) claims that the initial cluster of Kabardian /t'p'en/ is an example of a cluster "which is simultaneously unitary and complex" (for reasons which are not relevant here), and as such should have a representation incorporating the complex segment analysis, as in (7.57):
while Hoard (1978:70), following his earlier analysis, suggests that syllabic stops and affricates in Northwest Pacific languages are also complex segments. In his analysis, a syllabic stop, say syllabic [t], consists of two parts:

The first column will contain the feature specifications that characterize consonantal and nonsyllabic t. The second column will be distinctively [+syll] and will have the feature specifications appropriate to a syllabic release.

Thus, "the complex segment [tT]" (where T stands for "the release portion of a syllabic voiceless stop") will be represented as (7.58):

\[
(7.58) \begin{array}{c}
-\text{syl} & +\text{syl} \\
-\text{cont} & +\text{cont} \\
+\text{cons} & -\text{cons} \\
-\text{voiced} & \\
-\text{sonor} & \\
+\text{coronal} & \\
+\text{anterior} & \\
\end{array}
\]

Finally, recall Goldsmith's suggestion (see §3.3) that within an SPE-type feature-matrix, falling pitch might be represented as a sequence of high pitch and low pitch within a single segment.

Such solutions, then, incorporate a new structural property into the segmental distinctive feature matrix of SPE, essentially a structural variable which allows sequential change within the segment. Notice that if this notion were to be directly incorporated into dependency phonology, we would have to decide whether there were motivations for suggesting a greater degree of structure between the two elements of a complex segment. In other words, is there reason to suppose that there should be dependency relations within the segment between non-simultaneous elements?
In the remaining sections of this chapter, I shall investigate this problem, and I shall suggest that there is a structural variable (apart from intra-segmental change) common to all of the consonantal phenomena mentioned above. Further, I shall claim that this structural variable is such that it isolates the so-called 'complex segments' from other segments and sequences, and as such, removes the need for a decision on the question of monosegmental or bisegmental analysis.

7.4.3 Prenasalised consonants

As we have seen, there have been various proposals concerning the characterisation of the segments which occur in the first column of (7.59) (from Ladefoged 1971:34), which displays phonological contrasts involving prenasalised stops in Tiv:

(7.59) 
| áa mbè  | á bêndè  | á mènà |
| 'she suckled' | 'he touched' | 'he swallowed' |
| á ndèrà | á dè  | á nèndà |
| 'he began' | 'he left alone' | 'he is backward in growth' |
| ñdzuûr | á dzèndà |  |
| 'he muddled' |  |  |
| á ndjìyòl | á dìngè | á ñándà |
| 'he spoke quickly' | 'he searched' | 'he urinated' |
| á ngòhòr | á gèmà |  |
| 'he received' | 'he turned around' |  |
| á ñìngbahom | á gòbèr |  |
| 'he approached' | 'he slashed' |  |

Herbert (1977:257) notes the existence of the Nyanja pair in (7.60), which contrasts a syllabic nasal followed by a voiced stop with a syllable-initial prenasalised voiced stop at the phonetic level (although the underlying forms, in Herbert's analysis, display a different relationship):

(7.60) /m+ bale/  [mbale]  (trisyllabic)  'brother'
/n+ bale/  [mbale]  (disyllabic)  'plate'

Herbert, who offers a comprehensive account of the analysis and behaviour of prenasalised consonants in a variety of languages, offers
the following "phonetic definition" of a prenasalised consonant:

A prenasalised consonant is formally defined as a necessarily homorganic sequence of nasal and non-nasal consonantal segments which together exhibit the approximate surface duration of 'simple' consonants in those language systems within which they function. (1977:16).

At the phonetic level, then, prenasalised consonants have the same length as other single consonantal segments, rather than clusters of two consonants. It is this fact, together with "the homorganicity of their components... and various other subtle phonetic adjustments which occur between the two components", which leads Herbert to treat them as units at the surface (phonetic) level.

Chomsky and Halle (SPE:317) treat prenasalised consonants as single segments, as does Ladefoged (1971:35), who suggests, in addition to the feature [nasality], a feature [prenasality], which:

must be defined in terms of the duration of an event. It is the duration of the velopharyngeal opening which occurs before another articulation such as an oral stop or fricative in circumstances which require the whole complex to be considered as one phonological unit.

Thus, prenasalised stops have the values [1 presnasy, 0 nasality]:

These monosegmental solutions are criticised by S. Anderson (1974, 1976), on the grounds discussed in §7.4.2. Much of his argument is based on the tendency of nasality in consonants "to spread into adjacent vowels" (1976:335). He notes that in Gbeya pure nasal consonants can be followed by nasal vowels, but prenasalised consonants must be followed by oral vowels. Similarly, he observes that Apinayé shows a series of voiced stops which may be nasal, prenasal, postnasal, or oral, depending on the nasality of the preceding and following vowels. The possibilities are as follows:

(7.61) [V b V] [V b d V]
[V m b V] [V m d V]
[V g m V] [V b n V]
[V m V] [V m n V]

Thus, the difference between the four surface varieties of voiced stops is shown to be allophonic. A single intervocalic voiced
stop (as in the first column) is oral between two non-nasalised vowels, as are intervocalic clusters of two voiced stops (as in the second column). A single intervocalic stop is prenasalised following a nasal vowel and preceding an oral vowel, and postnasalised if the reverse is true, while the first member of an intervocalic cluster takes its nasality from the preceding vowel, and the second from the following vowel:

The generalization to be drawn from these facts is: the first portion of a consonant (cluster) between vowels has the nasality of the preceding vowel, while its second portion has the nasality of the following vowel. Where the vowels differ, the result is a 'complex nasal contour'. If there are two segments on which to realize this contour, each specification takes one segment as its domain; but if there is only one, a complex nasal consonant results. (1976:337).

This evidence leads Anderson to claim that features such as "[pre-nasal], [nasal], [postnasal], etc. quite miss the point, in that such features cannot be taken to have the entire segment as their domain." Rather, it is in relative timing (either within the segment or across segment-boundaries) that they differ, and it is for this reason that he proposes the analysis in (7.55) and (7.56).

A rather similar case from Sinhalese is cited by Feinstein (1979:251). In Sinhalese, a nasal consonant nasalises a contiguous vowel, rather than the other way round:

(7.62) a. meē 'this'
b. dee 'thing, sg. def.'
c. māsē 'month, sg. def.'
d. isnānē 'bath, sg. def.'
e. āmmē 'mother, sg. def.'
f. bōnTe 'to drink'
g. kāndē 'hill, sg. def.'

However, forms with prenasalised consonants show nasalisation only on the preceding, not the following vowel:
Using the formalism of (7.56), the representations of (7.61) can be characterised as (7.64):

<table>
<thead>
<tr>
<th></th>
<th>V</th>
<th>m</th>
<th>V</th>
<th></th>
<th>V</th>
<th>m</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>syll</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td></td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>cons</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td></td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>nasal</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
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</tr>
</tbody>
</table>

Anderson's solution, then, clearly incorporates the possibility of features having as their domain stretches of the speech-sound both larger and smaller than the segment.

Herbert (1975:108-109, 1977:151-152) cites a third type of analysis in which prenasalised consonants are treated as single consonants, at least at the surface level, that of Myers (1974). Myers proposes the use of vector features, which represent a "changing, vectoring value over the duration of the segment". In particular, she proposes the vector (or movement) feature [early velar closure]: prenasalised consonants ([+nasal, +early velar closure]) are treated as a sub-class of nasal consonants.

Herbert (1975, 1977) considers prenasalised consonants to be phonologically sequences of nasal +consonant. He argues that in Luganda, for example, the "so-called prenasalised consonants...
tion in separate syllables until very late in the application of phonological rules" (1975:120). At the abstract level, then, the nasal and oral components of a surface prenasalised stop derive from independent nasal and oral segments in different syllables, while, as we have seen, Herbert considers them to be units at the phonetic level. Thus, in the Runyankore forms in (7.55) and (7.56), all of which display surface prenasalised consonants, the source of the nasal component of the prenasalised consonant is taken to be a separate nasal segment: in (7.55), the nasal component derives from a separate underlying morpheme; in (7.66) the nasal component derives from the same morpheme as the oral component. Herbert notes that the prenasalised consonants in (7.65) are phonetically identical to those in (7.66); as the nasal component in (7.65) must originate independently from the oral component (as it forms a separate morpheme), there is no reason to suppose a different source from those in (7.66) (from Herbert 1977:275-276):

(7.65) embango /e + N + bango/ 'spear shafts'
embindl /e + N + bIndl/ 'pots'
enteNgkye /e + N + te N + kye/ 'small cows'
ndeebire /N + reebire/ 'I saw'
anteera /a + N + teera/ 'he hits me'
mwakingkorera /mu + aa + kl + N + kor + era/ 'you (pl.) did it for me'

(7.66) oruvaluja /o + ru + baNja/ 'judgement'
omuntu /o + mu + Ntu/ 'person'
eblicoño /e + bl + coNco/ 'gifts'
kwenda /ku + eNda/ 'to go'
aryatandika /a + rya + taNdika/ 'he will begin'

As Herbert notes (1977:285), the nasal component of a morpheme-initial prenasalised consonant cannot derive from the coda of a preceding syllable. However, he observes that such prenasalised consonants are extremely infrequent; "the vast majority of initial prenasalised consonants arise from morphological prefixation". Herbert suggests that when such consonants do occur, they are derived from underlying syllabic nasals, as in (7.67):
Herbert also considers the problem of the characterisation of prenasalised consonants at the surface phonetic level, i.e. the level at which he considers them to be units. He proposes the incorporation of phonetic vector specifications, which differ from the vector features proposed by Myers, in that they "make use of ordinary, motivated features and incorporate the same information as an ad hoc feature postulated to account for the movement of articulators within a single segment. Thus, for example, the continuant specification for (7.67) would be [++cont]." (1977:185). Thus, prenasalised voiced stops and fricatives would be represented as (7.68) and (7.69) respectively:

(7.68) \[ +\text{voi} \]
\[ +\text{cont} \]
\[ +\text{nas} \]

(7.69) \[ +\text{voi} \]
\[ +\text{nas} \]
\[ +\text{cont} \]

Feinstein (1979) offers a not dissimilar phonological characterisation of the prenasalised consonants. Noting that these consonants can only occur in syllable-initial position he claims that:

in a theory of phonology which incorporates a direct representation of syllable structure... 'prenasalized consonants' and ordinary NC (homorganic nasal-oral consonant) clusters alike are represented as sequences of discrete homorganic nasal and oral consonants. (1979:246).

Thus Feinstein abandons the monosegmental approach of Anderson, and the way in which he distinguishes between the Sinhalese forms in (7.70) (1979:247):

(7.70) a. kanda 'trunk, sg. def.'
    b. kanda 'hill, sg. def.'

Rather, Feinstein distinguishes between the two forms by means of different syllable structures, as in (7.71):

(7.71) a. ka$nde
    b. kan$de
"The representations in (a) and (b) involve no purely segmental distinction." Notice that Feinstein observes that, at the phonetic level, the difference in the relative duration of the nasals in (a) and (b) might have to be characterised; this, however, does not function "in any linguistically significant way".

Feinstein, too, points out the difficulties which Ladefoged's system would have in accounting for data such as (7.62) and (7.63), in that all prenasalised stops are [+nas] (as well as being [+pre-nas]), and so the Sinhalese rule nasalising vowels contiguous to nasal consonants, which he formalises as (7.72), should affect vowels following prenasalised consonants too:

\[(7.72) \text{ [+syl]} \rightarrow \text{ [+nas]} \% \text{ [+nas]}\]

(where % denotes the use of the mirror-image convention). Indeed, Feinstein claims (1979:252) that:

monosegmental analyses of this sort all fail to capture
the obvious generalization about 'prenasalized consonants'
with respect to vowel nasalization, namely that they be-
have as though they are clusters of nasal and oral consonants.

As noted above, Feinstein considers prenasalised stops to be tautosyllabic, and, further, always to form a syllabic onset. He claims, indeed, that this is the defining characteristic of what are usually characterised as prenasalised consonants, while phonetically identical clusters which are not tautosyllabic are not so interpreted. He sets up a mechanism for determining syllable boundary placement in Sinhalese, which I shall not go into further here, and, as a result, presents the following analysis of singular and plural forms involving intervocalic 'sequences' of N+C:

The singulars contain ordinary heterosyllabic NC clusters, whereas the plurals exhibit 'prenasalized consonants'; the latter are represented hereinafter, following the sequential analysis suggested earlier, as surface NC syllable onsets. (1979:271):
Inanimate Definite Nouns

<table>
<thead>
<tr>
<th>Singular</th>
<th>Plural</th>
<th>Gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. kan$da</td>
<td>ka$ndu</td>
<td>hill</td>
</tr>
<tr>
<td>b. hom$ba</td>
<td>ho$mbu</td>
<td>chin</td>
</tr>
<tr>
<td>c. han$da</td>
<td>ha$ndi</td>
<td>spoon</td>
</tr>
<tr>
<td>d. kon$da</td>
<td>ko$ndu</td>
<td>backbone</td>
</tr>
<tr>
<td>e. an$da</td>
<td>a$ndi</td>
<td>fence</td>
</tr>
</tbody>
</table>

I do not intend to consider the motivations for the particular syllabification rules which Feinstein proposes. Rather, what I want to suggest is that various aspects of the models of prenasalisation discussed above (at least of those incorporating some sort of 'complexity' or bisegmental assumption) can be reconciled by appealing to the model of phonological structure which I have been outlining in the previous chapters. The apparent difference between the various analyses is, I suggest, due to a failure to take account of the kinds of structural properties inherent in the dependency model.

Feinstein (1979:255) notices that the 'sonority hierarchy' theory of syllable structure discussed in §7.2 predicts that a syllable-initial prenasalised stop is unexpected: "in an /$ndV/ syllable... the sonority of the initial nasal is greater than that of the following stop". Herbert (1977:87), too, observes that the fact that the order of components in prenasalised consonants is contrary to the sonority hierarchy is "a singly important piece of evidence traditionally cited as pointing to the unitary status of prenasalized consonants". Thus, a syllable which begins with a prenasalised stop violates the general principles of syllable structure discussed in §7.2.3. In dependency terms, a nasal is more |V|-like than a voiced stop, and so is expected to occur nearer the syllabic. In terms of sequence, this is not the case. However, if (as in the case of the [sC] clusters mentioned in §7.2.3) we maintain the expected hierarchical relation between the nasal and the stop, such that the stop is dependent on the nasal, the representation of, for example, Tiv /mbè/ will be:
(7.74), then, shows a characterisation of the prenasalised stop in which 'reversed dependency' is apparent. Similarly, the difference between Sinhalese /kənde/ (/ka$nde/ in Feinstein's syllabification) and /kanda/ (/kan$de/) would be:

(7.75) a.

(7.75) b.

(In (7.75) I use the 'overlap' analysis proposed by Anderson and Jones; hence in (7.75b) /d/ is ambisyllabic, while in (7.75a) the prenasalised stop belongs only to the second syllable - as we have seen, these items can occur only syllable-initially.)

Thus, prenasalised stops are invariably represented by a 'reversed dependency' structure, while 'normal' N+C clusters are not (assuming the validity of Feinstein's claim that prenasalisation can only be a feature of syllable onsets). What I want to claim, then, is that such structures (represented in abstract form as (7.76)) are associated with the deviant behaviour of these elements:
A structure like (7.76), then, reflects the ambivalent nature of elements such as 'prenasalised consonants'. Their status as two phonetic elements is reflected by the sequential ordering relation between A and B, while the fact that they behave as a single phonological unit can be associated with the counter-sequential dependence of B on A. Thus I am suggesting that in such reversed dependency structures the two 'segments' involved show a greater degree of intimacy than normal sequences. This analysis, I shall claim, is also appropriate for the characterisation of the various phenomena to be discussed in the remainder of the chapter.

The characterisation of prenasalised consonants in these terms, I think, compatible with either a unit or a cluster approach. Although the nasal part and the oral part of, say, /nā/ are under separate nodes, and may therefore be interpreted as distinct segments, it seems equally possible to suggest that the presence of the reversed dependency structure represents not two phonological segments, but two phonetic events functioning as one phonological unit, or at least showing greater intimacy than in the unmarked case, where relative sequential distance from the syllabic correlates with relative hierarchical distance. The 'deviant' structure, then, characterises the deviant nature of such elements, and the controversy surrounding their segmental status is, in this model, shown to be a function of their structure. Whether we call prenasalised consonants one segment or two, phonologically, is, I think, unimportant within the dependency model - their unique status is characterised by making use of the greater richness of phonological structure available within this model than within the frameworks employed by S. Anderson, Herbert, and Fein-stein (or indeed by Ladefoged and SPE). Further, notice that the fact
that prenasalised consonants occur only syllable-initially is naturally reflected in the framework proposed here - in syllable-final position such consonants would show the regular dependency structure.

The discussion here does not bear on Herbert's arguments for the derivation of prenasalised consonants (from a source where they form segments in different syllables) to give a surface form in which they form phonetic units. Rather, I am concerned only with the characterisation of such units.

The analysis of postnasalised stops such as those in (7.61) will proceed in a similar fashion. Postnasalised stops (or 'prestopped nasals') have the "distributional and phonological properties of single segments" (S. Anderson 1976:332), and seem to occur only syllable-finally. Thus Hyman (1975b:256) - cf. Herbert (1977:317) - cites the 'partial denasalisation' rules of Land Dayak which have the effect of creating a postnasalised stop in word-final position:

(7.77) 'cloth'

/kain/

[kaɪ̯d̜̯n̥] (N + C N / [nasal] V)

where the function of the process appears to be to prevent the spreading of nasality into the previous vowel.

In the dependency model, [kaɪ̯d̜̯n̥] will have the tree in (7.78):

(7.78)

where we again see the reversed dependency structure, this time in postvocalic position, so that the oral stop component precedes the nasal stop component, and is dependent on it.
S. Anderson (1976:335) reports a third type of element, a 'medio-nasalised' stop [b̩mb], which occurs as a conditioned variant of prenasalised stops in Kaingâng. Herbert (1977:328-329) notes that such forms arise as a result of a 'shielding' process, which serves to maintain the orality of an underlying oral vowel occurring contiguously to an underlying nasal consonant. This shielding process yields four allophones of underlying /m/, as in (7.79):

\[(7.79) \quad /m/ \rightarrow [m] \quad /\tilde{V} \quad \tilde{V} \]

\[\quad [\tilde{m}b] \quad /\tilde{V} \quad V \]

\[\quad [\tilde{b}m] \quad /V \quad \tilde{V} \]

\[\quad [\tilde{b}\tilde{m}b] \quad /V \quad V \]

where the resulting pre-, post-, and medio-nasalised consonants serve to provide an oral stop component between the nasal consonant and the oral vowel. The representation in (7.80) would seem appropriate for medio-nasalised segments:

\[(7.80)\]

where both the oral components are dependent on the nasal, which is in turn dependent on both syllabics.

I have not discussed in detail the characterisation of the 'spread' of nasality from nasal consonants into contiguous vowels (in the case of Sinhalese) or from nasalised vowels into contiguous consonants (in the case of Apinayé), or of the shielding processes just described. I shall discuss in chapter 8 the characterisation of nasalised vowels, and will return to this problem in greater detail there; however, notice that the difficulties which were noted in a monosegmental analysis of pre- and post-nasalised consonants with respect to nasal spreading are not apparent within the dependency model. Nasal
spread is dependent simply on the sequential order of nodes (whether or not these nodes are interpreted as separate segments). Thus, Sinhalese \([-k\text{\textbar}n\text{\textbar}a]\) and \([-k\text{\textbar}n\text{\textbar}d\text{\textbar}a]\) both show nasalisation on the first vowel because it is contiguous to a nasal 'node', and not on the second, which is not contiguous to such a node; rather, it is contiguous to an oral 'node'. Similarly, Apinayé sequences such as \([-V\text{\textbar}t\text{\textbar}m\text{\textbar}V]\), \([-V\text{\textbar}b\text{\textbar}n\text{\textbar}V]\), \([-V\text{\textbar}m\text{\textbar}b\text{\textbar}V]\), and \([-V\text{\textbar}m\text{\textbar}d\text{\textbar}V]\) show nasalisation spreading into the contiguous stop; if, simultaneously, an oral vowel on the other side of a single consonant or consonant cluster inhibits nasalisation, then nasal spread will be prevented from affecting the whole consonant or cluster, thus giving a pre- or post-nasalised stop in the case of a single consonant, and a cluster of nasal followed by oral stop, or oral followed by nasal stop, in the case of a consonant cluster. In chapter 8, these processes are given a more formal characterisation.

7.4.4 Affricates

As was noted in §7.4.2, the characterisation of affricates with respect to the monosegmental/bisegmental interpretation problem has been a matter of controversy in the literature (see, for some discussion, Sommerstein 1977:28-29). The differing views are apparent at the level of traditional phonemic transcription systems: as Campbell (1974:59) notes, affricates in the IPA transcription tradition are given the 'complex symbol' representations /tʃ/ and /dʒ/, while American tradition uses the unitary symbols /z/ and /j/.

It is clear that, phonetically, two distinct 'events' are involved in the production of affricates - a closure phase and a friction phase - whether or not these are interpreted as two phonological segments. As such, they are held by many to be identical to those sequences of stop and (homorganic) fricative which are not considered to be affricates. Representative views are to be found in various introductory books: thus Abercrombie (1967:148) observes:

When the friction following the stop is sufficiently marked to be considered a separate segment, the cluster of stop and homorganic fricative is usually known as an affricate ... the term is only used when it is convenient to treat the cluster as a single phonological unit.
Gimson (1970:173) notes that RP /tʃ, dʒ/ "will here be treated as complex phonetic but single phonemic entities", while Catford (1977:211) remarks:

Generally speaking, we reserve the term 'affricate' just for those sequences of stop and homorganic fricative that occur within one and the same syllable, and that are regarded, for a variety of reasons, not necessarily phonetic, as representing unit phonemes in a given language. Thus, although the final [ts] in German Spatz [spats] and English cats [kats] may be phonetically identical, we generally call the former an 'affricate', but the latter merely a sequence of stop plus fricative.

Finally, Sommerstein (1977:28) concludes that "it is ... best to proceed on the assumption that the existence of such contrasts [i.e. between affricates and stop/fricative sequences] cannot be determined".

However, Newton (1972:132-134) appears to make a phonetic distinction between [tˢ] and [ts] in dialects of Modern Greek spoken in Rhodes, as in [pěatˢi] 'child' from underlying /peâdki/, but [látshi] 'wells' from underlying /lákki/ and [papútsi] 'shoe' from /papútsi/, where [tˢ] is a "voiceless dental affricate". In many dialects, he observes, 'degemination' (of /kk/) operates to remove the distinction between [tˢ] and [ts] (all of the forms turning up as the affricate), but "in Rhodes ... the absence of degemination still permits an opposition in terms of length: [tˢilá]:[tsilá]". Similarly, Herbert (1977:440) gives the following set of Polish minimal pairs, which appear to show a phonetic difference between "unit and non-unit stop-fricative sequences":

<table>
<thead>
<tr>
<th>(7.81)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>czech [ężɛ̞x]</td>
<td>'Czech'</td>
<td>trzech [tʃɛ̞x]</td>
</tr>
<tr>
<td>czysta [ɕi̞sta]</td>
<td>'clean' (fem.)</td>
<td>trzysta [tʃi̞sta]</td>
</tr>
<tr>
<td>paczy [paɕi]</td>
<td>'warps'</td>
<td>patrzy [pɔtʃi]</td>
</tr>
<tr>
<td>oczyma [oɕima]</td>
<td>'eyes' (instr.)</td>
<td>otrzyma [ɔtʃima]</td>
</tr>
<tr>
<td>czy [ɕi]</td>
<td>'whether'</td>
<td>trzy [tʃi]</td>
</tr>
</tbody>
</table>

(Notice, however, that, as in the Greek set, the opposition between the affricates and the stop-fricative sequences is often not apparent; the 'non-unit' sequences being commonly replaced by the affricates.)
Newton and Herbert's evidence might appear to support an analysis in which affricates are treated as monosegmental, although Catford's argument does not. Let us assume, in any case, that at least phonologically, our system of representation must enable us to make a distinction between the two categories - affricates and sequences of stop+fricative.

The kinds of solutions proposed within feature theory parallel quite closely those made for the prenasalised consonants discussed in the previous section. Chomsky and Halle and Ladefoged have monosegmental analyses: for Chomsky and Halle affricates are distinguished from stops by means of a feature [delayed release], affricates being [+del rel], by virtue of the fact that the closure phase is released more slowly than in the production of a stop, and from fricatives by being [-cont]. Ladefoged uses two features [stop] and [fricative] to cross-classify the three categories - stops are [1 stop, 0 fricative], fricatives are [0 stop, 1 fricative], while affricates have positive values for both features, thus allowing us to show "that affricates are related to both fricatives and stops" (1971:55).

Complex segment analyses are proposed by various phonologists, as discussed in §7.4.2 (Hoard 1967, 1971, 1978, St Clair 1972, 1973, Campbell 1974). One of the areas in which proponents of the complex segment theory claim that the monosegmental analysis is inadequate is 'amalgamation' rules, "by which I mean rules in which unit segments are produced by a convergence of underlying separate segments" (Campbell 1974:61). Thus Campbell claims that a rule such as (7.82), which amalgamates the sequence [t][§] to produce the affricate [t§] fails to reveal the relationship between the two:

(7.82) 
\[
\begin{array}{c}
\text{t} \\
-\text{continuant} \\
+\text{anterior} \\
+\text{coronal}
\end{array} + \begin{array}{c}
\text{§} \\
+\text{continuant} \\
-\text{anterior} \\
+\text{coronal}
\end{array} \rightarrow \begin{array}{c}
\text{+delayed release} \\
-\text{anterior} \\
+\text{coronal}
\end{array}
\]

There is no real change in feature composition, for both the articulatory gestures of t and § are still present in the affricate, and the only real change is in their unitary status.
This, however, is not revealed by the formulation in (7.82). A similar rule would presumably be required for those dialects in Rhodes which have collapsed the [ts]/[t\sp{3}] distinction. In the complex segment analysis, these amalgamation rules would have the form in (7.83):

(7.83) \[
\begin{array}{c}
\text{[-continuant] + antterior} \\
\text{+coronal}
\end{array} +
\begin{array}{c}
\text{[+continuant] - antterior} \\
\text{+coronal}
\end{array} +
\begin{array}{c}
\text{[-continuant] + antterior} \\
\text{+coronal}
\end{array}
\]

Hoard (1975:34-35) offers exactly the same criticism, this time with respect to Puget Salish, an Amerindian language, in which there are rules which have "the effect t + s → c (=[t\sp{3}s]) and d + s → j (=[d\sp{3}z]) ... it is obvious intuitively that d and s 'fuse' into j; but the [SPE] formalism tends to obscure this".

It is not immediately obvious how affricates are to be characterised within dependency phonology. In that they consist of two phonetic units functioning as a single phonological unit, we might expect them to show the same kind of reversed dependency structure as that proposed for the prenasalised consonants, and, indeed, Anderson and Jones (1977:126) propose (without defending their choice) (7.84) as the appropriate representation for (voiceless) affricates:

(7.84) C
    \[\begin{array}{c}
    V:C
    \end{array}\]

Thus, a word such as English <check> might have the categorial representation in (7.85):

(7.85) C
    \[\begin{array}{c}
    V:
    \end{array}\]

Similarly, the distinction between (Rhodes) Greek [t\sp{3}l\acute{a}] and [ts\acute{a}], or Polish [czyx] and [t\acute{y}x], might be shown as (7.86) and (7.87):
However, the structures in (7.85) and (7.86) diverge from the normal syllable structure in rather a different way than the structure postulated for prenasalised consonants in §7.4.3. In setting up the reversed dependency structure for these elements, I argued that this was appropriate in that the more sonorant element preceded the less sonorant element, and as such, should be the governor. However, this is not the case in Anderson and Jones's analysis of the affricates. Rather, (7.87) displays the expected structure (in that fricatives are more [V]-like than the stops), while the suggested structure for affricates deviates from the expected pattern. We may refer to this kind of reversed structure as showing 'dependency reversal', and the kind displayed by prenasalised consonants as 'sequence reversal'. There appears at first sight to be no phonetic justification for the reversed structure in the case of dependency reversal. If this structure is to be incorporated into the system of representation, then, we must find arguments from other areas.

We have seen that most of the arguments for the phonological status of affricates have involved the claim that they are phonetically identical to stop+fricative sequences. The arguments for setting up affricates as units, then, are purely phonological; there is no necessary aspect of the phonetic signal to justify the claim (although there may be phonetic justification in the case of, for example, Rhodes Greek). Bearing this in mind, it seems that the justi-
fication for structures like (7.85) must be phonological; associated with the claim that a stop + fricative sequence forms a single phonological unit in a particular language is the reversed dependency structure, which appears to be characteristic of 'complex segments'.

The difference between (7.86) and (7.87) does not appear to characterise the difference in length, which, Newton claims, exists between \([t^s]\) and \([ts]\). However, notice that the prenasalised consonants discussed in §7.4.3 also have the length of a single segment. The reversed dependency structure represents successive nodes which function as a single phonological unit, but notice also that in these reversed structures the first node is more intimately related to the syllabic than in normal structures, as in (7.88) and (7.89):

(7.88) \[\begin{array}{ccc}
A & B & C \\
\end{array}\]

(7.89) \[\begin{array}{ccc}
A & B & C \\
\end{array}\]

Thus, in (7.88), \(A\) is directly dependent on \(C\), while in (7.89) it is merely subordinate to \(C\). We might argue, then, that it is to be expected that in (7.88) \(A\), more intimately related to \(C\) than in (7.89), is also temporally more closely related; therefore it is not surprising that the duration of the consonantal structure in (7.86) is potentially less than the 'normal' structures exemplified by (7.87).

A further argument for the structure in which \(|C|\) governs \(|V:C|\) would involve the claim that affricates are a sub-class of stops, rather than fricatives. Indeed, such a categorisation is inherent in Chomsky and Halle's feature system, where stops and affricates are \([-\text{cont}]\), as opposed to fricatives, but not in Ladefoged's system, in which affricates differ 'equally' from stops and fricatives. Herbert (1977:163-164) appears to suggest that affricates function more often
with stops than with fricatives; and it seems likely that affricates typically develop historically from stops (perhaps via aspiration), rather than from fricatives.

If the reversed dependency structure is adopted for affricates, RP <judge> /dʒʌdʒ/ will have the representation (7.90):

(7.90) V
   /C;V  C;V/
   /V,C;V V,C;V/

In postvocalic position, then, affricates have the 'expected' dependency shape, in that the final element (the fricative phase of the affricate) is dependent on the penultimate (the stop phase); however, the reversed dependency structure is still apparent, in that the more sonorant element is still dependent on the less sonorant. Thus, we have both sequence and dependency reversal, yielding an apparently 'non-reversed' configuration. Notice, too, that in postvocalic position we do not find contrasts in length between affricates and stop+fricative clusters (of the [tʃ] vs. [ts] sort noted by Newton in prevocalic position); we have already seen that Catford claims that final /ʃs/ in German is phonetically identical with the final sequence /ts/ in English. In this case, then, it seems appropriate that we do not have a structure in which the element further from the nucleus ([ʒ]) governs the element nearer to the nucleus ([d])—such a structure would imply, on the argument outlined above, the possibility of phonetic shortening.

The question remains, however, as to what exactly the appropriate structure for final /ts/ clusters in English should be. In that /s/ is more sonorant than /t/, we might expect (7.91) to be suitable:

(7.91) V
   /C  V:C/
   /C /kæts/
However, (7.91) implies that /ts/ has a unit status, which contradicts normal phonological analyses of these clusters in final position. Similarly, if /s/ is taken to be dependent on /t/, we have the structure already proposed for affricates (cf. (7.90)).

It is not clear to me exactly what the solution to this problem might be. One possible line of argument would be the following. The English /ts/ (and /dz/) clusters arise only as a result of morphological processes (plural formation, 3rd person present tense formation, possessive formation). They do not occur intramorphemically (with the exception of a very few words such as <adze> /ædz/). It seems at least possible that, in such morphological processes, the realisation of the bound morpheme (/s/ or /z/) does not function in the same way in the syllable as when it is intramorphemic, but, rather, is attached directly (and uniquely) to the governor of the free morpheme, as in (7.92), the tree for <cats>:

(7.92)

\[
\begin{array}{c}
  \text{V} \\
  \text{C} \quad \text{C} \quad \text{V:C}
\end{array}
\]

If this solution can be given some independent phonetic support, we are able to distinguish this kind of structure from those discussed above.

Given the arguments of the last two sections, it is clear that prenasalised affricates, such as those in the Tiv data given in (7.59) (e.g. /á ndzu'Ur/, /á ndʒɔyɔ/) will be given a representation involving a reversed dependency structure with three nodes. Notice that Herbert (1977:159), using Campbell's complex segment proposal, characterises the prenasalised affricates as (7.93):

(7.93) \[
\begin{bmatrix}
  +\text{cons} \\
  -\text{voc} \\
  +\text{voice} \\
  +\text{nasal} \\
  +\text{ant} \\
  +\text{cor} \\
  -\text{cont} \\
  +\text{cont}
\end{bmatrix}
\]
The dependency representation of such structures will be:

(7.94) ![Diagram of dependency representation]

7.4.5 Preaspiration

In this section I consider a phenomenon whose treatment in dependency terms appears to be rather different from those discussed in the previous two sections, but whose interpretation, nevertheless, has raised problems with respect to its status as a phonological segment. Various languages show preaspirated consonants, for example, Gaelic, Icelandic (as already noted in chapter 3), and various dialects of the other Nordic languages, while Welsh provides an example of a language with preaspirated vowels. For a general discussion of preaspiration, see Kylstra (1972).

As in the case of prenasalised consonants and affricates, there has been some discussion in the literature as to whether preaspirated consonants should be interpreted phonologically as one segment or two. Borgström (1940:20-21), for example, gives pairs in Lewis Gaelic which show an opposition between preaspirated and unaspirated stops:

(7.95) glac [glablK] 'grasp!' (imper.)
glag, clag [glag] 'a bell'
at [aht] 'a fester'
ad [ag] 'a hat'

Borgström considers the possibility of regarding the preaspirated stops "as groups of consonants (h + occlusive)", but rejects this possibility because, among other reasons, "the preaspiration is shorter than an ordinary h in the same dialect, and shorter than that of
the group *h* etc. in the southern dialects*. Thus, he interprets the Lewis preaspirated stops as single phonemes. However, preaspiration in the other dialects which Borgström (1940, 1941) considers is given a different characterisation. In these dialects, the sequence of preaspiration + stop is treated as a group of two phonemes, partly because of the length of the [h]-segment - "Ross dialects have occlusives preceded by a very distinct and long h" (1941:100) - and partly because the preaspiration is not only realised by [h], but also by [x] and [c]. Thus we find the transcriptions in (7.96) for the Ross-shire forms:

(7.96) cat [kʰɑʰt] 'cat'
      boc [bɔhk] 'a buck'

As Herbert (1977:86) points out, the phonetic sequence [kʰɑʰt] is said to be "the realization of three underlying phonemes . . . /kʰ/ /ɑ/, and /tʰ/" in the Lewis dialect, while in the other dialects the string [kʰɑʰt].(which Herbert calls "phonetically identical") is composed of four underlying phonemes: /kʰ/, /ɑ/, /h/, and /t/.

Ternes (1973:57ff), in considering the Applecross dialect of Scots Gaelic, argues that "the sequences resulting from historical preaspiration are interpreted partly monophonemically, partly biphonemically*. Thus, "fricative + stop" sequences occurring medially and finally, which do not have mirror-image counterparts in initial position, are interpreted as biphonemic /çp çf çk/. All "[h]+stop" sequences, "which do have mirror-symmetrical counterparts in initial position", are monophonemic: /pʰ tʰ tʰ kʰ kʰ/. These phonemes have initial "postaspirated" allophones [pʰ tʰ], and final "preaspirated" allophones [h pʰ tʰ].

Various views have been put forward with respect to the Icelandic data presented by Thráinsson (1978), which was given as (3.33), and is repeated as (7.97):

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>feit</td>
<td>[feiːtʰ] 'fat'</td>
</tr>
<tr>
<td>ljót</td>
<td>[ljouːtʰ] 'ugly'</td>
</tr>
<tr>
<td>sát</td>
<td>[salːtʰ] 'sweet'</td>
</tr>
</tbody>
</table>
Icelandic shows two series of voiceless stops - unaspirated \( {bdg} \), as in the words \( \text{labb, rödd, egg} \) (Haugen 1958:72) and aspirated \( \text{p tk} \), as in the first column of (7.97). The two series can be represented phonetically as \( \text{[p tk]} \) vs. \( \text{[ph th kh]} \). Notice that if the \( \text{p tk} \) series is preaspirated, as in the second column of (7.97), they are not also (post-)aspirated.

Haugen (1958:72) argues for a treatment of the 'fortis' series of stops (\( \text{p tk} \)) in which both preaspiration and postaspiration are interpreted as "components of fortis stops; in each case the aspiration occurs on the side of the consonant closest to the syllabic". Thus, in Haugen's model aspiration is the defining factor of the \( \text{p tk} \) series. The appropriate phonemic representations for the two series, then, are \( \text{/bd g/} \) and \( \text{/pt k/} \), and (7.98) shows the phonemicisation in Haugen's system of some words displaying preaspiration (from Thráinsson 1978:6):

\[
\begin{align*}
(7.98) & \quad \text{kappi} \quad [\text{khahpi}] \quad /\text{kapi}/ \quad \text{'hero'} \\
& \quad \text{pakka} \quad [\text{thetaeka}] \quad /\text{paka}/ \quad \text{'thank'} \\
& \quad \text{hattur} \quad [\text{hahtyr}] \quad /\text{hatyr}/ \quad \text{'hat'}
\end{align*}
\]

Haugen, then, treats the aspirated series as single phonemes, and aspiration to be allophonically stated; thus \( \text{/p/} \) may have realisations such as \( \text{[ph]} \) and \( \text{[hp]} \), while \( \text{/b/} \) is realised as \( \text{[p]} \).

Haugen criticises Malone's (1923) analysis of the same phenomena for its "great inconsistency" in treating postaspiration as a component of the stop, but preaspiration as a separate phone. Malone, then, offers a bisegmental analysis of preaspiration, but a single segment analysis of postaspiration. However, this is perhaps not such an inconsistency as Haugen appears to think. As Thráinsson (1978:5) points out, preaspiration at the phonetic level "typically has a normal segment length in Icelandic, whereas postaspiration is generally much shorter". Pétursson (1972a:66) notes:

Sur le plan de la durée, qu'on compare d'une part les chiffres moyens d'aspiration vs. préaspiration et d'autre part d'aspiration +cons. ocl. vs. préaspiration +cons. ocl. Il est évident que la différence de durée est trop grande pour qu'il puisse s'agir du même phénomène qui se présenterait dans un ordre inverse.
Phonetically, then, preaspiration and (post-)aspiration are rather different phenomena, and this leads Thráinsson to accept Malone's view, and also to adopt the phonetic notations \([\text{hp}]\) vs. \([\text{ph}]\):

\[(7.99)\]  
\[
\begin{array}{ll}
\text{hatur} & [\text{h}a\text{t}^\text{h}\text{yr}] \quad /\text{hatyr}/ \quad \text{'hate'} \\
\text{hattur} & [\text{h}a\text{t}^\text{y}r] \quad /\text{hattyr}/ \quad \text{'hat'} \\
\text{haddur} & [\text{h}a\text{t}^\text{y}r] \quad /\text{haddyr}/ \quad \text{'hair'} \\
\end{array}
\]

Notice, too, that Thráinsson (1978:4) points out that "post-aspiration is a very common phenomenon, while preaspiration seems to be very rare".

Thráinsson offers a representation of the aspiration phenomena of Icelandic in terms of distinctive features, as noted in chapter 3. Thus the sequence \([\text{ht}]\) in \(<\text{hattur}>\) has the representation in (7.100):

\[(7.100)\]  
\[
\begin{array}{ccc}
\text{laryngeal} & \text{phonological} & \text{supralaryngeal} \\
\text{features:} & \text{segments:} & \text{features:} \\
[+\text{spr.gl.}] & C_1 & [+\text{son}] \\
[-\text{constr.gl.}] & & [-\text{lab}] \\
[+\text{stiff v.c.}] & & [+\text{cor}] \\
[-\text{slack v.c.}] & C_2 & [-\text{high}] \\
\end{array}
\]

where \([\text{h}]\) is treated as lacking any specification for supralaryngeal features, but as showing the laryngeal feature specifications for the following stop. A postaspirated stop, however, is treated as a single segment, and has simply the representation in (7.101) for the laryngeal features, while the unaspirated series has (7.102):

\[(7.101)\]  
\[
\begin{array}{ccc}
[+\text{spr.gl.}] & & \\
[-\text{constr.gl.}] & & \\
[+\text{stiff v.c.}] & & \\
[-\text{slack v.c.}] & & \\
\end{array}
\]

\[(7.102)\]  
\[
\begin{array}{ccc}
[-\text{spr.gl.}] & & \\
[-\text{constr.gl.}] & & \\
[+\text{stiff v.c.}] & & \\
[-\text{slack v.c.}] & & \\
\end{array}
\]

As in the cases of the phenomena discussed in the previous two sections, we are again confronted with a situation where both one- and two-segment analyses have been suggested. An analysis in terms
of the dependency model, I suggest, tends to provide evidence favouring Þráinsson's two-segment analysis of preaspiration.

Clearly, however, the elements of the dependency model developed in the previous chapters are not adequate to account for the preaspiration phenomena of Icelandic. In particular, we have as yet no way of representing the opposition between the voiceless aspirated stop series and the voiceless unaspirated stop series. In order to show how the dependency model can be applied to this area, I shall anticipate some of the more detailed arguments of chapter 9.

In Ewen (forthcoming a), and in chapter 9 below, it is argued that the representations of the initiatory gesture must include a component of glottal opening, represented as \([0]\). This component, roughly comparable to the multivalued feature [glottal stricture] in the Ladefoged framework, is needed to account for voiceless sonorants, among other things. Voiceless sonorants, which differ from voiced sonorants in having a greater degree of glottal opening and no vocal cord vibration, show governing \([0]\) in their representations:

\[
(7.103) \quad \begin{array}{c}
0 \\
V \\
\text{voiceless vowels}
\end{array} \quad \begin{array}{c}
0 \\
V \\
\text{voiceless nasals}
\end{array} \quad \begin{array}{c}
0 \\
V, C \\
\text{voiceless liquids}
\end{array}
\]

In the representations of (7.103), the presence of governing \([0]\), denoting a large degree of glottal opening, overrides the voicing specification inherent in the representation of the sonorants, thus capturing the fact that segments with a large degree of glottal opening do not show vocal cord vibration, while retaining the characteristics of the sonorants, necessary because these segments retain traces of the formant patterns typical of the voiced sonorants. In chapter 9 I give a formal and more detailed account of these matters.

The component \([0]\) appears also to be appropriate for the charac-
terisation of the phenomena I have been discussing in this chapter, and of aspiration in general. It has been argued in various places that degree of aspiration correlates with degree of glottal opening. Thus Kim (1970:111) states that "if a stop is \( n \) degree aspirated, it must have an \( n \) degree of glottal opening at the time of release", while Catford (1977:114) observes that "modern techniques of glottography and laryngoscopy show that unaspirated voiceless sounds have a narrowed (though not completely closed) glottis, while aspirated sounds have a more or less widely open glottis". Similarly, Pétursson (1976:187), in a study of aspiration in Icelandic, concludes:

L'examen de glottogrammes de consonnes aspirées et non aspirées semble pour l'essentiel confirmer qu'en islandais l'aspiration peut être décrite comme une fonction de l'ouverture glottale au moment de l'explosion.

In dependency terms, then, it seems that aspirated segments show a more prominent \( [\_0] \) than corresponding non-aspirated segments.

As noted above, Icelandic has an aspirated and an unaspirated series of stops, both of which are voiceless. In terms of the representations of the categorial gesture developed in chapter 6, then, both series have the representation \( [C] \). They differ in the relative prominence of \( [\_0] \): for the aspirated series, \( [\_0] \) is governing, while for the unaspirated series, \( [\_0] \) is dependent, as in (7.104):

\[
(7.104) \quad \{[\_0 \top C]\} \quad \{[C \top \_0]\}
\]

\[
/\text{p t k}/ \quad /\text{b d g}/
\]

\[
[\text{ph th kh}] \quad [\text{p t k}]
\]

The representations in (7.104), then, incorporate the assumption that the monosegmental analysis of the aspirated series is correct; that is, postaspiration is taken to be a component of the aspirated series, an interpretation which appears to be supported by the phonetic evidence mentioned above. Notice too that although the series /bdg/ is said to be 'unaspirated', it is not the case that \( [\_0] \) is absent in the representation. Rather, such segments show some glottal opening, and so display (dependent) \( [\_0] \). The absence of \( [\_0] \) (in a phonological representation which contrasts with segments which do display \( [\_0] \)) would characterise a glottal stop (cf. chapter 9).
The analysis of preaspirated stops, however, is rather different. I assume, following Thráinsson, that preaspirated stops are bi-segmental; or at least that they are sequentially distinct in a dependency tree, whether or not such a configuration is to be equated with the occurrence of two segments (cf. the discussion in the previous sections). How, then, is the period of preaspiration itself to be represented?

As Thráinsson points out, preaspiration in Icelandic is realised phonetically as [h]. In §5.1, we saw that [h] can best be characterised as a segment lacking any specification in the articulatory gesture, and is therefore to be defined as a voiceless fricative with no articulatory specification. However, what I want to argue is that the preaspiration 'segment' in Icelandic has a rather different specification. '[h]' in such cases, then, still lacks the articulatory specification - cf. also the Thráinsson specification in (7.100). However, instead of being characterised as |V:C|, it is characterised by the presence of |O| alone, as in (7.105), which represents the surface form of <feitt> (neuter sg.) 'fat':

(7.105)

There are two ways of justifying this analysis. Notice first of all that Thráinsson's characterisation of [h] ([+spread gl., -constr.gl., +stiff v.c., -slack v.c.]) is interpretable within this model as |O| alone. On the principles outlined in chapter 4, a segment containing a particular property occurring alone displays more of that property than if it occurs in combination with other properties: thus, in this case, the segments show maximal glottal opening. Secondly, the choice of |O| rather than |V:C| is appropriate because of the nature of the opposition between the /p t k/ and /b d g/ series
in Icelandic. As the opposition is one of aspiration, and \(|0|\) is already required in the phonological characterisation of the language, then the choice of \(|0|\) to represent \([h]\) reflects its phonological status as a period of aspiration, rather than as a voiceless fricative.

It is also necessary to account for the fact that the preaspiration 'segment' governs the stop in (7.105). I suggest that aspiration in Icelandic may be viewed as a kind of prosody whose domain may be the whole consonant (cluster) forming a syllabic onset or coda. (A similar proposal is apparently made by Liberman 1971 - see Pétursson 1972b.) This is parallel to Thráinsson's claim (1978:38-39) that preaspiration is an autosegment which can behave independently, and is "capable of such behaviour as moving or floating from the stop where it originated in phonological specification". If this is so, Thráinsson claims:

\[
\text{this sort of movement should have two consequences: First, it should make the stop unaspirated, since it would no longer be specified as \([+SG]\). Secondly, if the preceding segment were voiced, we would expect it to become voiceless, since the feature \([+SG]\) refers to a wide open glottis.}
\]

Evidence that this treatment might be appropriate comes from the fact that preaspirated consonants in Icelandic are never postaspirated. Thráinsson notes (1978:49) that if a vowel follows a preaspirated stop it is not also postaspirated. Secondly, I noted above that Haugen (1958:72) observes that aspiration occurs on the side of the consonant closest to the syllabic: "preaspiration excludes postaspiration... the position of this aspiration is a matter to be stated in the allophonic rules". Compare also Pétursson's remark (1976:174) that "après \(h\), la consonne occlusive n'est jamais aspirée".

If only one occurrence of \(|0|\) is to be associated with each cluster, at least in Icelandic, then (7.106) appears to be a better way of representing the rhyme of a syllable containing a preaspirated stop than the corresponding structure in (7.105):
where the \(|O|\) governs the following stop. The claim inherent in (7.106) is parallel to that made by Thráinsson (1978:§5.4). He notes a number of phenomena which indicate that the "spreading of the glottis that one would expect to go with the stop is absorbed by the pre-aspiration segment". In other words, the stop itself is deaspirated. This leads Thráinsson to propose the following rule, accounting among other things for the deaspiration of /p t k/:

\[
(7.107) [-\text{syl}] [+\text{SG}] \Rightarrow [+\text{SG}] [-\text{SG}]
\]

where the [+SG] specification is transferred to the '[h]' segment.

As we saw in (7.97), forms such as /[feiht]/, with preaspirated stop in the neuter singular form of the adjective, contrast with words such as /[fei:th]/, with an ordinary aspirated stop in the feminine singular form. Representations such as (7.106), then, contrast with those such as (7.108), representing the (relevant part of the) surface form of the feminine singular form:

\[
(7.108) V
\]

\[
O;C
\]

Thus, the forms in (7.106) and (7.108) are shown to differ in whether or not strict precedence holds between the \(|O|\) and \(|C|\) nodes.

Further evidence for the appropriateness of this analysis comes from the behaviour of clusters of sonorant+stop. As Thráinsson (1978:39) shows, these clusters are realised differently in different dialects in Modern Icelandic, as in (7.109):
(7.109) úlpá 'coat' [úlpá] [ulpʰa] *[úlpʰa] *[úlpá]
heimta 'demand' [heimtʰa] [heimtʰa] *[heimtʰa] *[heimta]
vanta 'luck' [vanta] [vantʰa] *[vantʰa] *[vanta]
vinka 'wave' [vīŋka] [vīŋkʰa] *[vīŋkʰa] *[vīŋka]

In the dialect represented in the first column the liquid is devoiced and the stop deaspirated, while in the second column the liquid is voiced and the stop aspirated (cf. also Pétursson 1972b:107, who notes the existence of "formes d'origine régionale comme stůlkʰa "jeune fille" qui se prononce dans le Sud et l'Ouest comme [stůlkʰa] et dans le Nord comme [stůlkʰa]”). However, as shown in columns 3 and 4, there are no dialects which show both devoicing and aspiration, or both voicing and deaspiration.

In Thráinsson's model, rule (7.107) accounts for the dialects in column 1 of (7.109). It is clear that the difference between the two columns consists in where the single specification of aspiration is realised; i.e. in the dependency model, whether |O| is realised on the sonorant or on the stop, as in (7.110) and (7.111):

(7.110) O
(7.111) V

In each case, only a single |O| appears in the tree, while the two unattested cases in columns 3 and 4 of (7.109) would show either zero or two occurrences of |O| in governing position:

(7.112) *O
(7.113) *V
(Notice that (7.113) is deviant in that, although the sequence is well-formed, it contains a surface unaspirated rather than aspirated stop - because |O| is dependent, whereas it derives from an underlying aspirated segment: for further discussion, see chapter 9).

Thus, clusters of sonorant + underlyingly aspirated stop show the same constraints as aspirated stops occurring alone, in that only a single governing |O| can occur. It is, however, apparent that there is no formal reason for (7.112) and (7.113) being unacceptable structures; in other words, we have not yet formalised the notion of a cluster prosody. I return to this matter in §9.4.

I turn now to the characterisation of preaspirated consonants occurring intervocalically. Consider the following set of data (from Thráinsson 1978:10):

(7.114)  
<table>
<thead>
<tr>
<th>Inf</th>
<th>Past</th>
</tr>
</thead>
<tbody>
<tr>
<td>máta [maːtʰa] 'meet'</td>
<td>mátti [maihtɪ]</td>
</tr>
<tr>
<td>veita [veiːtʰa] 'grant'</td>
<td>veitti [veihtɪ]</td>
</tr>
<tr>
<td>nýta [niːtʰa] 'utilize'</td>
<td>nýtti [nihtɪ]</td>
</tr>
</tbody>
</table>

which show contrasts between intervocalic aspirated and preaspirated stops. In the case of the aspirated series, the following structure seems appropriate (I ignore the details of the characterisation of the other segments):

(7.115)  
```
      V
     / \   \    
    V   C  O; C
```

For the preaspirated series, I suggest that the only difference involves the relative precedence of |O| and |C|, with no change in the dependency relations, as in (7.116):
If (7.116) is appropriate, we again see the reversed dependency structure associated with a phonetic sequence which has sometimes been interpreted as a single phonological unit.

I return to a more detailed account of the Icelandic preaspiration rules in chapter 9, where I also discuss other aspects of the behaviour of |0| in phonological representations.

Finally in this section, I consider briefly a different kind of preaspiration - preaspiration of vowels. In Modern Welsh, there is a process of aspirate mutation, which has the effect of inserting an [h] segment before an initial vowel under certain grammatical conditions, notably after the feminine possessive adjective, as in (7.117):

(7.117) ei eglwys 'his church' [i egiols]
ei heglwys 'her church' [i heglois]

It has been argued that Welsh, like Icelandic, is a language in which the opposition of aspiration, rather than that of voicing, is relevant to the phonological system (see Griffen 1975, Ewen forthcoming c, and chapter 10 below). Hence, it seems that the representation of this [h] should be |0|. A preaspirated vowel, then, will simply have the representation in (7.118):

(7.118) V

Notice that, as in the cases discussed previously, |0| is dependent on |V|. That is, the preaspiration is not interpreted as having
the vowel within its domain, but, rather, as characterising the syllable onset, which, in this case, does not contain any consonants. The \(|V|\), as the characteristic element of the syllable, is its governor, and therefore governs \(|O|\).

7.4.6 sp, st, sk clusters

The final area which I want to deal with under the heading of phonological phenomena which have been interpreted both as single segments and as sequences of segments at the phonological level involves the analysis of clusters of \([s]\) followed by a stop. Such sequences occur both syllable-initially and syllable-finally in many languages, as in the following Dutch and English examples:

(7.119) spelen 'to play' wesp 'wasp'
    stelen 'to steal' kast 'cupboard'

(7.120) spate wasp
    state chest
    skate bask

(Notice that /sk/ has been lost syllable-initially in standard Modern Dutch, and has been replaced by /sx/; cf. Eng. <skate> and its Dutch cognate <schaatsen> /sxaːtsən/: in syllable-final position it has been replaced by /s/; cf. Eng. <fish>, Du. <vis> /vis/, and Norwegian <fisk>. Initial [sk] does, however, occur in certain loan-words in Dutch, e.g. <scooter> [skutər].)

The analysis of these clusters (which I shall transcribe as \([sC]\) for the purpose of the discussion) raises some of the same problems as have been noted above. Phonetically, as noted in §7.2.2, syllable-initial \([sC]\) clusters violate the syllabic hierarchy, in that \([s]\) is more sonorant than the stop. Typically, \([s]\) in such clusters takes a distinct chest pulse, or "burst of muscle drive" (Catford 1977:90). Phonologically, the clusters deviate in various ways from the normal patterns in languages. They show different distributional
properties from other clusters; notably, they can occur both syllable-
initially and syllable-finally, whereas, as noted in §7.2.2, syllable-
final clusters in a language are generally the mirror-image of syl-
llable-initial clusters (e.g. /pr-/ vs. /-rp/, /kl-/ vs. /-lk/). In
addition, as Kuyśłowicz (1971:195) notes, [sC] clusters deviate from
the normal alliteration rules "in the inherited Germanic verse".
While initial p- may alliterate with clusters such as pr- and pl-,
and h- with hr-, hl-, and hn-, s- may not alliterate with sk-, sp-, st-, nor
sk- with sp-, sp- with st-, etc. Rather, "sk can alliterate with sk,
st only with st, sp only with sp"

These facts, which I shall discuss more fully below, have led
some phonologists to analyse [sC] as a single phonological unit, al-
though these sequences have more usually been given a bisegmental ana-
lysis. In such bisegmental analyses, the [s] is identified with /s/
in, for example, English <sate>, Dutch <seinen> 'to signal', and the
stop is identified either with the /pt k/ series, or with the /bd g/
series, or is treated as an archiphoneme - for discussion, see David-

The fact that [sC] sequences violate the syllabicity hierarchy
leads Anderson and Jones (1977:125) to propose that they, like the
prenasalised consonants discussed in §7.4.3, show a reversed depend-
ency structure, as in (7.121):

(7.121)

\[ \text{i} \quad \text{t} \]
\[ \text{s} \quad \text{t} \]
\[ \text{p} \]

in which "the degree of dependency accords with prominence of |V|",
thus giving a structure in which [s] governs [p].

In what follows, I shall discuss the various arguments put
forward for a monosegmental analysis of [sC], arguments which tend to
support the reversed dependency structure proposed by Anderson and
Jones. This structure, I shall argue, displays the same properties
as that proposed for prenasalised consonants, in that it reflects the unitary status of [sC] ([p] in (7.121) being directly dependent on [s], and not on the vowel). However, a structure like (7.121) does not compel a treatment of [sC] as a single segment; rather, it shows that two chronologically distinct 'events' are involved. This is not apparent in the various unitary analyses to be discussed below.

Arguments for the unitary status of [sC] clusters come from various sources. Vogt (1942:14), for example, notes that [sC] in Norwegian, unlike other clusters, can form both initial and final clusters. All other initial xy clusters cannot occur finally, but can occur finally in the reverse order, i.e. as yx. "The clusters sp- etc. do not behave as the other clusters, they behave in all respects as single phonemes." Thus we find initial and final st and sk, and also initial st-r-, sk-r- vs. final -r-st, -r-sk in Norwegian. This leads Vogt to characterise [sC] clusters as "composite phonemes". If they are so treated, then the violations of the syllable structure rules are eliminated; initial (sC)r- (i.e. xy) parallels with final -r[sC] (i.e. yx), where x is the composite phoneme /sC/ and y the phoneme /r/.

Sigurd (1965:62) offers a similar argument, noting that the distribution of sp, st, sk and "the related stops p, t, k b, d, g" in initial clusters in Swedish is very similar, and notices, too, the problem of identifying "the sounds after s" as [ptk] or [bdg]. (7.122) shows the possible initial clusters of this type in Swedish:

(7.122)

<table>
<thead>
<tr>
<th></th>
<th>r</th>
<th>l</th>
<th>v</th>
<th>j</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>sp</td>
<td>spr</td>
<td>spl</td>
<td>-</td>
<td>spj</td>
<td>-</td>
</tr>
<tr>
<td>p</td>
<td>pr</td>
<td>pl</td>
<td>-</td>
<td>pj</td>
<td>-</td>
</tr>
<tr>
<td>b</td>
<td>br</td>
<td>bl</td>
<td>-</td>
<td>bj</td>
<td>-</td>
</tr>
<tr>
<td>st</td>
<td>str</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>t</td>
<td>tr</td>
<td>-</td>
<td>tv</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>d</td>
<td>dr</td>
<td>-</td>
<td>dv</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>sk</td>
<td>skr</td>
<td>-</td>
<td>skv</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>k</td>
<td>kr</td>
<td>kl</td>
<td>kv</td>
<td>-</td>
<td>kn</td>
</tr>
<tr>
<td>g</td>
<td>gr</td>
<td>gl</td>
<td>-</td>
<td>-</td>
<td>gn</td>
</tr>
</tbody>
</table>

Kohler (1967:51) offers rather different reasons for treating [sC] as a unit. He interprets /sp, st, sk/ in English as "single sequential elements", partly because it would be arbitrary to interpret
the "stop section as /p, t, k/", and partly "to separate the inherent structures /sp, st, sk/ from the alien ones /sf, sv/", which are interpreted as biphonemic sequences.

Fudge's (1969) arguments are primarily concerned with syllable structure. He claims that the onset of English syllables contains two 'places', the first of which may be filled by various phonemes, as shown in (7.123), which lists the (relevant) possibilities given by Fudge (1969:268):

(7.123)

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>p</td>
<td>t</td>
<td>č</td>
<td>k</td>
</tr>
<tr>
<td>2</td>
<td>w</td>
<td>l</td>
<td>r</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>s</td>
<td>p</td>
<td>st</td>
<td>sk</td>
</tr>
</tbody>
</table>

It will be seen that in (7.123) [sC] clusters are treated as single phonemes. Fudge claims that this is preferable to an alternative analysis, given as (7.124), in which [sC] clusters are treated as biphonemic, in that:

it avoids the necessity of postulating an extra place in the syllable structure (place 0) at which a system of only one element operates, and which must be filled by zero except when place 1 contains p, t, k, m, n, and perhaps f, v; other advantages include the avoidance of an arbitrary decision on whether to identify the stop portion of [sp] with the stop of series a (i.e. [p]) or that of series b (i.e. [b]). (1969:273):

(7.124)

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>s</td>
<td>p</td>
<td>t</td>
<td>č</td>
</tr>
<tr>
<td>1</td>
<td>b</td>
<td>d</td>
<td>j</td>
<td>g</td>
</tr>
<tr>
<td>2</td>
<td>w</td>
<td>l</td>
<td>r</td>
<td></td>
</tr>
</tbody>
</table>
Kuryłowicz (1971) interprets [sC] clusters as being neither unitary phonemes nor biphonemic sequences, but as being "phonological compounds". He cites evidence to support this claim from various sources, such as alliteration, and the behaviour of initial and final clusters. He notes that in Latin, Gothic, and English, an opposition exists in word-final position between -sT and -Ts (i.e. [sC] [-Cs]), but in word-initial position only sT- ([sC-]) occurs:

\[(7.125) \text{word-final} \quad -sT : -Ts \]
\[(7.125) \text{word-initial} \quad sT-\]

The phonological status of sT- (taken as a whole, not its components) is therefore different from that of -sT. The latter is, as against the former, permutable. The elements of -sT are on an equal footing. Each of them may occupy the first or the second place within the cluster. Not so in sT-, where the order of the elements is rigid. (1971:197).

This leads Kuryłowicz to draw a parallel between syntactic compounds and sT-; as the defining feature of compounds is their rigid order, sT- is to be treated as a phonological compound. This in turn leads to the claim that clusters of three consonants are to be considered as "dichotomous groups with different degrees of internal cohesion". Thus, initial str- in the languages under consideration shows a structure in which s and t show the greatest internal cohesion, and together form a group with r, as in (7.126):

\[(7.126) \quad [(s+t) + r]\]

or, in the form of a phrase structure tree, as (7.127):

\[(7.127)\]

```
  /\  
 /   \ 
s    t  r
```

Notice further that the alliteration processes cited by Kuryłowicz show that the presence of /r/ does not affect the ability of
[sp], [st], and [sk] clusters to alliterate with themselves. Thus, we find [st] alliterating with [str] in the data from Beowulf which Kuryłowicz gives as an example:

(7.128) 212 on stefn stlʒon; stréamas wundon

More evidence that [sC] clusters show greater internal cohesion than other clusters comes from their tendency to show metathesis with [Cs] clusters. Thus we find English <ask> occurring as [aiks], <wasp> as [waɪps], and Dutch <wesp> 'wasp' as [weɪps], and <gesp> 'buckle' as [geɪps].

There is, then, a great deal of evidence to support the view that the elements of [sC] clusters are, at least, more intimately linked than those of normal consonant clusters, whether or not this means that they should be interpreted as single segments. Cygan (1970) attempts to offer an explanation of this fact in terms of a Jakobsonian distinctive feature framework. He gives the following feature characterisation of the English voiceless fricatives:

(7.129) /f/ /θ/ /s/ /ʂ/
  [diffuse grave strident] [diffuse acute mellow] [diffuse acute strident] [compact acute strident]

Cygan claims:
The position of /s/ is unique among the spirants in English. It is the only spirant that does not possess any feature not shared with some other spirant; in fact it shares each of the three features with two other spirants.

Thus, /s/ is the "unmarked" spirant, in that each of the others is marked by the presence of a feature exclusive to itself; i.e. grave for /f/, mellow for /θ/, compact for /ʂ/. The stops with which /s/ forms [sC] clusters have the following characterisations:

(7.130) /p/ /t/ /k/
  [diffuse grave mellow] [diffuse acute mellow] [compact grave mellow]
Cygan applies the same marking procedure to the stops:
We can univocally define /k/ as compact and /p/ as grave; /t/ will then remain as unmarked, but in comparison with the unmarked /s/, it will contrast as mellow with its stridency.

It is difficult to see that this characterisation is not arbitrary; it seems equally possible to define /p/ 'univocally' as diffuse, /t/ as mellow, and /k/ as grave, or /p/ as mellow, /t/ as acute, and /k/ as grave. The basis for Cygan's particular choice is the hierarchicalisation of the features in (7.131):

(7.131) (Tense) spirants
\[
\begin{align*}
\text{diffuse} & \quad \text{compact} \\
\text{grave} & \quad \text{acute} \\
\text{mellow} & \quad \text{strident} \\
\end{align*}
\]

However, Cygan offers no independent motivation for the hierarchical ordering in (7.131); again, an apparently equally natural alternative can be constructed, as in (7.132):

(7.132) (Tense) spirants
\[
\begin{align*}
\text{acute} & \quad \text{grave} \\
\text{mellow} & \quad \text{strident} \\
\text{diffuse} & \quad \text{compact} \\
\end{align*}
\]

The choice of (7.131) in preference to (7.132) can be defended
by the fact that only (7.131) is compatible with a similar hierarchy of the stops, thus allowing Cygan's characterisation referred to above. It is this that allows Cygan to make the claim that in \([sC]\) clusters, "each of the stops supplies one of the three essential differentiating distinctive features negatively manifested in the spirant", as in (7.133):

\[
\begin{array}{cccc}
/s/ & /k/ & /p/ & /t/ \\
[non-grave] & & & \\
[non-mellow] & & & \\
\end{array}
\]

[(7.133)] may be an explanation for the strict parallelism and the very strong cohesion of these clusters. The essential bond that holds them together seems to be the attraction within the turbulents class between the unmarked continuant and a contrastively marked non-continuant in each case.

However, Cygan's argument, as noted above, does not seem to constitute a phonetic argument in any real sense for the status of \([sC]\) clusters. Rather, it appears merely fortuitous that the features yield the parallelism of (7.133).

Davidsen-Nielsen (1975) claims that the distributional behaviour of \([sC]\) need not be regarded as evidence for their unitary status - or indeed for a status different from that of other consonant clusters - in view of Basbøll's theory of the syllable discussed in §7.2. 2. In this theory, voiceless stops and voiceless fricatives belong to the same category in the syllabic hierarchy, and so, Davidsen-Nielsen claims, the fact that both \([sC]-\) and \([Cs]-\) (and both \([-sC]\) and \([-Cs]\)) can occur is to be expected. However, as we have seen, the only reason that voiceless stops and voiceless fricatives occur in the same category is the fact that \([sC]\) clusters would otherwise violate the syllabic hierarchy. Thus Davidsen-Nielsen's argument seems to be circular in this respect.

The various arguments and pieces of evidence cited above tend to support the interpretation of initial \([sC]\) clusters as displaying a reversed dependency structure as in (7.121). In syllable-final
position, [stC] clusters will show a regular structure, as in English <past> /paːst/:

\[(7.134)\]

\[
\begin{array}{c}
V \\
\quad V:C \\
\quad C \\
\quad C
\end{array}
\]

Similarly, English structures ending in a sequence of stop followed by /s/ will be given the characterisation outlined in §7.4.4.

The interpretation of [stC] clusters as having a reversed dependency structure has other advantages. Such structures can occur intervocalically in English, as in <fester> /festər/. In the overlap theory of the syllable, such words are divided into syllables as in (7.135):

\[(7.135) \text{[festər]}\]

and are the only words in English to show syllable boundary placement such that two consonants are ambisyllabic - because of the fact that [stC] are the only clusters which can occur both syllable-initially and syllable-finally. If these clusters are given a reversed dependency structure, then the structure associated with <fester> will be:

\[(7.136)\]

\[
\begin{array}{c}
V \\
\quad V:C \\
\quad V:C \\
\quad V:V:C \\
\quad C
\end{array}
\]

in which only the /s/ is directly dependent on the two vowels. Thus, a universal constraint can be maintained that only one consonant can be simultaneously directly dependent on two syllabics. In other cases where we have more than one intervocalic consonant, we find:
Finally in this section I consider the analysis of clusters consisting of [sC] followed by another consonant, as in English <screw> /skruː/. Such clusters consist of the [sC] structure followed by a more sonorant consonant, as in (7.139):

(7.139)

\[
\begin{array}{c}
\text{V} \\
\text{V;C} \\
\text{V;V,C} \\
\end{array}
\]

in which the /r/ shows the expected dependency relation with [sC], thus reflecting the fact that this relation is phonologically normal (cf. the alliteration phenomena cited above). Such clusters occurring intervocalically also show the expected structure:
We have seen in this chapter that various phonological phenomena have been interpreted as single phonemes, as sequences of two phonemes, or as 'complex segments'. In the dependency system of representation, it seems plausible to interpret all of these as displaying a reversed dependency structure, either involving sequence reversal or dependency reversal, thus allowing us to represent, within the notational system itself, their deviant phonetic and/or phonological characteristics, while not committing us to a decision on whether they are to be interpreted as single phonemes, complex phonemes, or sequences of phonemes.
Chapter 8

The Articulatory Gesture

In this chapter I consider the representations of the articulatory gesture, or perhaps more accurately, the locational gesture. I discuss first the representations of vowels, and then go on to consider consonants, although, as might be expected, the representations for the two categories are not entirely distinct.

8.1 Vowels: the basic vocalic components

In §3.1 I discussed the framework of natural phonology, and in §4.3 showed that this framework shared some basic concepts with the model of dependency phonology. In particular, we saw that the vowel space could be characterised by three dependency components, repeated here as (8.1):

\[(8.1) \quad \begin{align*}
| & [i] \quad ('\text{palatality}') \\
| & [u] \quad ('\text{labiality}') \\
| & [a] \quad ('\text{sonority}')
\end{align*}\]

I do not propose to examine again the way in which these properties can characterise the vowel space in a dependency system (for this see the discussion in §4.3). Nor do I intend to consider any further the various kinds of distinctive feature proposals for the representation of vowels (but see again §§2.1 and 2.2, and Ewen forthcoming b for a discussion of some of the problems associated with feature representations of vowels - in particular of the RP vowel system). Rather, I want to examine in rather more detail the assumptions apparent in §§3.1 and 4.3, i.e. that vowels should be defined
by properties such as those in (8.1). The discussion will be in two parts - firstly, whether there should be such properties, and secondly, if so, what exactly the phonetic correlates of these should be.

As is well known, there is a great deal of evidence to support the view that /i/, /u/, and /a/ are the phonologically least complex vowels. Jakobson (1941:50) shows that the fundamental vocalic triangle contains /i/, /u/, /a/; these are the three vowels acquired earliest by the child, and represent also the minimal vowel system of languages of the world. For Jakobson, such a system is "characterised fundamentally by the presence of phonemes which contain two distinct qualities". /u/ is narrow compared to /a/, and velar (or rounded) compared to /i/. It seems reasonable, then, to assume that our components should characterise these three extremes of the triangle.

There are, in fact, good phonetic reasons underlying the status of vowels in the [i], [u], and [a] regions as phonologically basic. It has been shown that these are just the vowels which are 'quantal'. This term is used by Stevens (1972) to characterise certain properties of these vowels. Specifically, these vowels have the property that more or less the same acoustic effect can be produced with a fairly wide range of articulatory configurations. In other words, the degree of articulatory precision required to produce these vowels is less than for other non-quantal vowels such as [ɪ], [ɛ], [æ], etc.

This acoustic effect is due to the convergence of certain formant frequencies for each of the vowels in question, resulting in distinct peaks in their spectra. For [i], F₂ and F₃ are both high, for [u], F₁ and F₂ are both low, and for [a], F₂ is low and F₁ is high. Stevens shows that this effect is maintained even though the tongue position is moved - i.e. that the perturbation caused by the position of the tongue in the supralaryngeal vocal tract may be displaced by up to a centimetre without affecting the acoustic signal. These facts indicate the acoustic basis for assuming /i/, /u/, and /a/ to be the most basic phonological vowels.

Such considerations lead Lieberman (1976:101) to propose a pho-
netic vowel theory in which "the quantal vowels /ɪ/, /ʊ/ and /ɑ/ de-limit the total acoustic vowel space that defines human speech". He illustrates this with (8.2), in which the first and second formant frequencies of the vowels of Swedish are plotted on a mel scale (derived from Fant 1969):

It will be seen from (8.2) that the two axes are labelled 'acute' and 'grave'. However, Lieberman explicitly rejects the binary assumption, and claims, rather, that these two axes define, in part, the vowel space, and that vowels can be characterised in terms of their relative gravity or acuteness. There are obvious similarities between this 'phonetic' theory and the kind of phonological theory outlined in §4.3, and it is phonetic evidence like this which provides support for the view that the kind of dependency characterisation being developed for vowels is appropriate and natural.

The second aspect of Lieberman's vowel theory:

is quite simple; it is that the quantal vowels being most useful - easiest to produce while yielding distinct acoustic signals - are the most highly valued vowels of human speech. Human beings have 'property detectors' in their auditory systems that are sensitized to fire when activated by formant frequency patterns that specify these vowels. There is, in other words, a 'match' at the neural level between the sound producing system of Homo sapiens and the auditory system. (1976:102).
It seems appropriate at this point to investigate further the phonetic properties corresponding to the basic components of the articulatory gesture. There are various parameters which might be used in the definitions of our components. \[i\], for example, is, in articulatory terms, high, front, and unround, and in acoustic terms, characterised by relatively high $F_2$ and $F_3$ (i.e. acute, in Jakobson's terms, as opposed to [i]), and a relatively low $F_1$ (diffuse, as opposed to more open vowels). Similar phonetic characteristics might be derived for [u] and [o], and, indeed, perceptual and other kinds of information might be introduced.

8.1.1 \[i\] and \[u\]

The main problem concerns the definition of the components represented as \[i\] and \[u\], and in what follows, I shall consider only high vowels, front and back, round and unround, i.e. [u], [i], [y], and [w]. In the Jakobsonian framework, these vowels are distinguished as in (8.3):

(8.3) plain vs. flat
- acute \(i\) y
- grave \(w\) \(u\)

The 'tonality' features (Jakobson et al 1952:28), flat vs. plain and acute vs. grave, combine to characterise the four possibilities. Flatting is manifested by a downward shift of a set of formants, and at the articulatory level can be associated with (among other things) lip-rounding. For acute segments, the upper side of the spectrum predominates, while for grave segments the lower side predominates: roughly speaking, if $F_2$ is nearer $F_1$ than $F_3$, the segment is grave; if $F_2$ is nearer $F_3$ than $F_1$, the segment is acute. Acute vs. grave is associated with cavity variation, and flat vs. plain with rounding variation.

Notice that Jakobson et al (1952:36) offer a somewhat ad hoc notational device for distinguishing "optimal grave" and "optimal
acute" vowels on the one hand from an "attenuated class, i.e. either flat acute or plain grave" on the other. "With this assumption /u/ is '+', /i/ is '-' and /y/ or /i/ is '+' vs. /i/, but '-' vs. /u/, and here may be symbolized as '±'."

The SPE system, using articulatorily based features, is shown as (8.4):

\[
\begin{array}{ccc}
\text{[-round]} & \text{vs.} & \text{[+round]} \\
\text{[-back]} & I & y \\
\text{vs.} & \\
\text{[+back]} & w & u \\
\end{array}
\]

(where [+back] characterises retraction of the tongue from the 'neutral' position).

The relationship between the front/back and round/unround parameters has been examined by Schane (1973b). The problem relating to (8.3) and (8.4) is that one or other of the tonality features (or 'cavity' features in SPE terminology) may be primary, depending on the language in question. Trubetzkoy (1939:§4.3) notices that three situations are possible. Firstly, tongue position may be primary and lip shape redundant, in languages such as Japanese, in which processes occur before u, o, a (a set of back vowels), but not before i, e (front vowels). Secondly, lip position may be primary and tongue position redundant, as in Russian, in which [i] and [u] are allophones of one phoneme, and [y] and [a] of another. Thirdly, there are languages in which neither can be considered primary, i.e. in Trubetzkoy's terms, the opposition is between front unround and back round, and is equipollent. "For triangular vowel systems (where there is one low vowel), Trubetzkoy considered the equipollent cases to be the most frequent" (Schane 1973b:175).

This leads Schane to consider the question of whether backness or roundness (i.e. gravity or flatness) should be considered primary for back rounded vowels. He notices that in redundancy-free feature-matrices it is often the case that either backness may be predictable from roundness, or roundness from backness. He considers a variety of
evidence which leads him to propose that for front unround vowels, frontness is primary, while for back round vowels, roundness is primary. His examples concern processes such as assimilation in Nupe (from Hyman 1970), in which consonants are palatalised before front vowels, and labialised before round vowels, but do not assimilate before /a/, a vowel which is neither front nor round. Similarly, in Icelandic, two umlauting processes occur. In i-umlaut, back round vowels become front under the influence of a following /i/; in u-umlaut, front unround vowels become round (not backed) under the influence of a following /u/. One of Schane's proposals is that instead of [back], the proper feature-name should be [front], as frontness is primary for vowels such as /i/, /e/, and /a/.

Such considerations appear to provide evidence for characterising [i] and [u] as follows. The basic articulatory correlate of [i] is frontness, or palatality, in Donegan's terms, and that of [u], roundness, or labiality. Acoustically, [i] is characterised by acuteness, and [u] by gravity, or flattening. These components, of course, are relative to any other components in a particular segment (cf. Lieberman's approach). A segment with [i] alone will be fronter and more acute than one in which [i] is combined with another component.

For a language such as French, then, with the vowels /i/, /y/, /u/, the dependency representations will be:

\[(8.5) \{[i]\} \quad \{[i,u]\} \quad \{[u]\} \]

\[/i/ \quad /y/ \quad /u/\]

Thus the two 'basic' series in Trubetzkoy's terms, i.e. front unround and back round, have the simplest representations, while the 'mixed' series, the front round, have more complex representations. Further, the natural phonology notions of bleaching and colouring are given a natural interpretation here. Bleaching, the removal of a colour, is interpreted as the removal of a component (e.g. \([i,u] \rightarrow [i]\)) while colouring is characterised as the addition of a component (e.g. \([u] \rightarrow [i,u]\)). The status of mixed vowels as less distinctive than pure ones ([Donegan] Miller 1973:388) is reflected in the representations. [i] and [u] alone are maximally distinctive,
containing the maximal possible degree of their respective defining characteristics, whereas the combination [i,u] is shown to be a 'mixture' of the different characteristics, producing a less distinctive vowel. Similarly, /y/, as the representative of Jakobson's "attenuated class", i.e. flat acute, is distinguished from the optimally acute vowel /i/, and the optimally grave vowel /u/, without recourse to Jakobson's dubious notational device.

8.1.2 Back unround vowels

The treatment so far suggests that the back unround vowel lacks both the components discussed in the previous section - it is not front and it is not round - and this corresponds to Donegan's characterisation of [w] as colourless or achromatic. Such vowels are not very common, presumably because of their lack of distinctiveness, reflected by their achromaticity or lack of dependency components.

Schane (1973b:1978), too, notices the rarity of the series, and offers the following explanation. For front vowels, lack of rounding is unmarked, and rounding marked, while for round vowels, the other basic series, back vowels are unmarked, and front vowels marked. "Consequently, marking either 'basic' series produces front rounded vowels." Back unround vowels, then, deviate in two respects from the maximally unmarked series.

The class of back unround vowels, as noted in §4.3, must be represented negatively, as (8.6):

\[(8.6) \sim \{i,u\}\]

i.e. as the class of vowels not containing /i/ or /u/. Such a representation shows the extreme complexity of this class of segments, while at the same time demonstrating their phonetic relationship with the other series of vowels. I return to this matter in §8.2.1.

8.1.3 /a/

/æ/, the third basic vocalic element, presents fewer problems.
In (8.1), this component was glossed as 'sonority'.

In Jakobson's model low vowels are compact, as opposed to diffuse - i.e. they show a relatively predominant centrally located formant region. As we have seen, [α] is characterised by a high $F_1$ and a low $F_2$. Associated with greater compactness is "a higher 'phonetic power' than with greater diffuseness" (Jakobson et al. 1952:28). It is this property which allows the natural phonologists ([Donegan] Miller 1973) to characterise the achromatic vowel property as 'sonority'; open vowels are more sonorous than close ones.

The vowel component [a], then, appears to correspond with maximal opening on the articulatory level, and maximal sonority on the acoustic level.

8.2 Central vowels

The set of vowel components developed so far is only adequate for the expression of a subset of the total set of vowels found in languages; specifically, no combination of [i], [ɯ], and [a] can account for central vowels such as [ə] and [ʉ]. [ə] is not front, not round, and not low, and as such any representation involving any one or more of [i], [ɯ], and [a], respectively the components of front- ness, roundness, and lowness (to use the articulatory glosses of the previous section), would be unnatural.

This suggests the need for a further vowel component - a component of 'centrality', which can be represented as [ə] (cf. Anderson and Jones 1977). While such a component is clearly necessary to allow for the representation of central (and centralised) vowels, as I shall show below, the data surveyed by Crothers (1978) appears to show that a component with a 'centrality' gloss is basic in much the same way as [i], [ɯ], and [a], rather than being a shorthand notation for $\wedge\{i, u, a\}$.

Crothers is concerned with the typology of vowel systems in languages, and considers a total of 209 languages. Of these, 23 are lan-
guages which have only three phonemic vowels. All of these have vowels which might be represented as /i u a/ (although the phonetic quality of the vowel may vary, Crothers 1978:109 claims that all 23 systems are of the same type, in that "the three vowels stand in the same relative relationship, and occupy the same regions of the vowel space"), and this confirms the phonological appropriateness of the three basic components already established.

22 languages have four-vowel systems, and these fall into two types. All four-vowel systems contain /i u a/, while the fourth vowel may be either a front mid vowel (of the /e/-type) or some kind of central vowel (usually /ɨ/ or /ə/). In the former case, i.e. a system containing /i e a u/, the dependency system established in §4.3 and the preceding gives the following representations:

(8.7) { |i| } { |i.a| } { |a| } { |u| }

where /e/ is given the expected characterisation. In the latter case, however, where the fourth vowel is central, (8.7) would be inappropriate. Rather, the fourth vowel (whether it is realised phonetically as [ə] or [ɨ], or even as [ω]) should have the representation |ə|, to give the system in (8.8):

(8.8) { |i| } { |a| } { |u| } { |ə| }

The existence of such languages, then, can be taken as support for the claim that there should be a basic centrality component in our notational system. Notice again that a representation like |ə| does not embody a claim about the precise articulatory quality of the vowel. Rather, as Crothers (1978:110) points out, "four vowels do not pack very efficiently into the vowel space, and this leaves room for the fourth or central vowel to move into different positions". A system such as (8.8) is the maximally simple one containing all four vowel components, as no relations of dependency or simple combination have to be postulated. I return below to the consideration of the most common vowel system types discussed by Crothers. First, however, we must investigate in greater detail the nature of representations containing |ə|. 
By and large, the principles which have been established concerning representations containing the other three basic components apply equally to those containing |ə|. For example, the vowels /i/, /o/, and /ʌ/ in RP, being respectively centralised front, centralised round, and central low vowels, might have the representations:

(8.9) {i, ə} {u, ə} {a, ə}

while /ə/ itself would be represented as {ə} alone. The representations in (8.9) are established on the principle that these vowels are the only ones in which combinations of centrality and each of the other basic elements are required (in RP), and hence there is no need to specify dependency relations between |ə| and the other components; simple combination is sufficient to characterise the vowels in question. Similarly, in a language such as Amharic (Crothers 1978:142), containing /i/, /i/, and /ə/, the representations {i}, {i, ə}, and {ə} are adequate to characterise the phonemic system in this area.

However, in a phonetic account of RP /i/, /o/, and /ʌ/ (see §8.3 below), or indeed in phonological representations where the important point is considered to be that these vowels are centralised rather than central, the representations in (8.10) might be more suitable:

(8.10) {i ə} {u ə} {a ə}

Representations such as those in (8.10) are employed in Ewen (forthcoming b), in which the RP short vowel system is given the following characterisation in terms of the dependency components under discussion here:

(8.11) /i/ ɪ;ə  /o/ ʊ;ə

/ə/ ɪ:a  /ə/ ə

/ʌ/ ə;i  /ʌ/ ə;ə  /ʊ/ ə;ʊ

In that the representations in (8.11) are intended to be rele-
vant to the needs of the foreign learner of English (in the context of Ewen forthcoming b), the characterisation of /i/, /o/, and /ʌ/ as involving subjunction of |e| seems more appropriate; as noted above, in a more abstract representation, simple combination seems sufficient. (For the characterisation of the RP long vowels and diphthongs, see §8.4, and for a similar approach to the Dutch vowel system, §11.3).

The introduction of |e| enormously increases the potential of the model as a system of representation adequate for the expression of finer phonetic detail than has been necessary at the kind of level discussed up to now, and I take up this matter in §8.3.

8.2.1 More on back unround vowels

In §8.1.2 I noted some arguments showing that back unround vowels are highly complex in phonological terms, and proposed that in our system of representation the set of back unround vowels might best be characterised as \( \sim\{i,u\} \), i.e. the class of vowels not containing |i| or |u|.

It is clear, however, that a vowel such as [w] bears close acoustic similarities to central vowels such as [+] and [e], and it appears to be for this reason that any of these can occur as the 'central' vowel representative in the four-vowel systems outlined by Crothers (1978), and characterised as (8.9). It is possible, then, to interpret a back unround vowel as being \{|e|\}, phonologically. In those cases, however, where the phonological analysis demands the characterisation of back unround vowels as containing \( \sim\{i,u\} \), the following representations are appropriate:

\[
\begin{align*}
(8.12) & \quad \{\sim\{i,u\}\} & \{\sim\{i,u\} \neq a\} & \{\sim\{i,u\} \neq a\} \\
/\nu/ & \quad /\nu/ & \quad /\nu/
\end{align*}
\]

Thus, Akha, which has, according to Lindau (1978:549), the system in (8.13), might have the dependency representations in (8.14)
(8.14) \{|i|\} \{|i, u|\} \{|\sim \{i, u\}\} \{|u|\} \\
\{|i \sim a|\} \{|i, u \sim a|\} \{|\sim \{i, u\} \sim a|\} \{|u \sim a|\} \\
\{|a \sim i|\} \{|a \sim u|\} \\
\{|a|\}

while Ngwe (Lindau 1978:550), with the system in (8.15), might have the representations in (8.16):

(8.15) \{i\} \{i, u\} \{\sim\{i,u\}\} \{u\} \\
\{i \sim a\} \{i, u \sim a\} \{\sim\{i,u\} \sim a\} \{u \sim a\} \\
\{a \sim i\} \{a \sim u\} \\
\{a\}

Notice that the representations for back unround vowels can combine with \{a\}, while \{i\} and \{u\} are of course excluded - a vowel cannot be simultaneously non-front and front, or non-round and round. Representations like (8.12) and (8.14), then, if required in the phonological characterisation of a language, bring out the highly complex nature of the system.

8.3 Phonetic representations

While the number of possible representations containing only \{i\}, \{u\}, and \{a\} remained quite small (a total of 19, given the constraints on representation which we have established), this becomes
much larger as soon as we introduce |ə|. This allows us, if we wish, to provide representations which may be **phonetically** more appropriate than those established on phonological grounds in previous sections, as we have already seen with respect to the RP centralised vowels. I do not propose to discuss this matter in any detail, but an indication of how the notation might be employed to characterise phonetically the vowels of (8.17) (i.e. all the primary and secondary cardinal vowels, together with some other common vowels) is given in (8.18):

(8.17)

(8.18) [i] {i} [y] {i,u}
[i] {i,æ} [y] {i,u,æ}
[e] {i,a} [ə] {i,u,a}
[ɛ] {i,a;æ} [ɛ] {i,a}
[a] {a;i} [ɛ] {a;i,u}
[ɨ] {i,ə} [u] {u,ə}
[œ] {i,ə,a} [œ] {u,ə,a}
[œ] {ə}
[œ] {a,ə}
[œ] {u,a,ə}
To some extent, of course, the representations in (8.18) are arbitrary; as the vowel area is a continuum, the assignment of representations in it is arbitrary. However, the representations are based on the definitions given for each of the basic components, and as such are natural. The appropriate area of the vowel trapezium can be identified by inspection of the representation alone. In addition, the vowel area could be divided into even smaller sections, each with its own phonetic representation, by utilising the many other possible combinations of the vowel components.

As my main concern is with the phonological, rather than the phonetic, representation of segments, I shall leave this matter here; however, this brief discussion will have served to indicate how the apparently rather abstract phonological representations can be mapped onto phonetic representations by language-specific realisation rules.

8.3.1 Some common vowel systems

Crothers (1978:105) shows that certain vowel systems are very common. The most common appear to be /i ɛ a u œ/, /i ɛ ɜ a u œ/ and /a u/, systems which in the dependency notation might have the representations below:

(8.19) {i} {iə} {a} {uə} {u}
     /i/ /ɛ/ /a/ /ə/ /u/

(8.20) {i} {iə} {a} {uə} {u} {œ}
     /i/ /ɛ/ /a/ /ə/ /u/ /œ/
Other common vowel systems which Crothers discusses are easily characterised within the dependency system:

(8.22) \{ |i| \} \{ |a| \} \{ |u| \}
     /i/ /a/ /u/

(8.23) \{ |i| \} \{ |a| \} \{ |u| \} \{ |ə| \}
     /a/ /a/ /u/ /t/

(8.24) \{ |i| \} \{ |a| \} \{ |a| \} \{ |u| \} \{ |ə| \}
     /i/ /e/ /a/ /u/ /t/

(8.25) \{ |i| \} \{ |i:a;| \} \{ |a;| \} \{ |a;| \} \{ |u;| \} \{ |u;| \} \{ |u| \}
     /i/ /e/ /e/ /a/ /o/ /o/ /u/

(8.26) \{ |i| \} \{ |i:a;| \} \{ |a;| \} \{ |a| \} \{ |a;| \} \{ |u;| \} \{ |u;| \} \{ |u| \}
     /i/ /e/ /e/ /a/ /o/ /o/ /u/

(8.27) \{ |i| \} \{ |i:a;| \} \{ |a| \} \{ |u.a;| \} \{ |u| \} \{ |i.e;| \} \{ |ə| \}
     /i/ /e/ /a/ /o/ /u/ /t/ /ə/

(8.28) \{ |i| \} \{ |i:a;| \} \{ |a;| \} \{ |a| \} \{ |a;| \} \{ |u;| \} \{ |u;| \} \{ |u| \} \{ |i.e;| \} \{ |ə| \}
     /i/ /e/ /e/ /a/ /o/ /o/ /u/ /t/ /ə/

There are, then, no common vowel system types in Crothers' survey which cannot be easily characterised by the notational system for vowel developed here. Further, the relative complexity of the systems is reflected in the expected way; i.e. by the number of basic components required to characterise the systems, and the kinds of relations required, simple combination, unilateral dependency, or bilateral dependency.

8.4 Long vowels and diphthongs

In §7.4.1 I showed that diphthongs and long vowels are best characterised within dependency phonology by a structure such as (8.29):
For long vowels, the two \( |V| \) nodes are identical, while for diphthongs, they are distinct. I argued in §7.4.1, following Lass (1976), that it is appropriate to characterise long vowels and diphthongs in the same way, as they form a phonological class opposed to short vowels. Further, I defended the particular structure in (8.29), in which the first vowel governs the second, on the grounds that it is appropriate for diphthongs in which the first element is more prominent than the second (i.e. 'falling' diphthongs, in traditional terms, such as \([ae], [iə] - see Catford 1977:216\). As we have seen, such a structure is also appropriate for long vowels, in that these segments form a natural class with the falling diphthongs.

Structures such as (8.29) clearly belong to the categorial gesture, and I return below to the way in which such structures are represented in the articulatory gesture. However, I want first to look again at some of the problems raised by the \( \text{SPE} \) treatment of the long vowels and diphthongs.

Diphthongs have traditionally been referred to as 'closing' or 'centring' (Catford 1977:217). Closing diphthongs are those in which the movement of the articulators is towards the roof of the mouth, while centring diphthongs are those in which the diphthongal movement is towards the centre of the vowel area, such as RP <pier> /p\text{i}ə/ , <pear> /p\text{ə}ə/ , <poor> /p\text{o}ə/ , <pour> /p\text{o}ə/ . Closing diphthongs may be either 'fronting', such as RP <sty> /st\text{ai}/ , <boy> /b\text{oi}/ , and Dutch <ui> 'onion' /\text{oi}/ , <ei> 'egg' /\text{e}i/ , or 'backing', such as RP <hoe> /h\text{e}ə/ , <cow> /k\text{ow}/ .

We have already seen (§7.4.1) that Chomsky and Halle attempt to characterise long vowels and diphthongs by means of the feature [tense], and I have discussed the undesirability of using such a feature. In addition, all long vowels and diphthongs, in the \( \text{SPE} \) account, are, by a rule of 'diphthongisation', given a homorganic post-
vocalic glide, [y] (i.e. [j]) or [w]. Thus, Chomsky and Halle claim (SPÉ:183) that, phonetically, all closing diphthongs end in an off-glide; i.e. something closer than either [i] or [u]. As we have seen, Lass shows that the notion that this is phonetically appropriate seems to be based on the phonemic representations of Trager and Smith (1951). In fact, as Lass argues, the second element of closing diphthongs is rarely as close as [i] or [u], and indeed Catford (1977:216) suggests that the second element of the English diphthongs in <tie> and <cow> may be as low as [e] or [ε] and [ɔ], i.e. [taæ] or [taε] and [kaʊ].

The SPÉ treatment of centring diphthongs also raises difficulties. Chomsky and Halle (SPÉ:205) suggest that the sequence [ʌʌ] may represent [ɔ] followed by a "centralizing glide" (i.e. a mid central vowel). Notice, however, that the characterisation of [ʌ] as a centralising glide or vowel does not square with the SPÉ feature assignment - [ʌ], in this framework, has the values [-high, -low, +back].

Phonetically, as we have seen, the second element of a diphthong is always vocalic, and, as Lass points out, there also seems to be no good reason for treating the second element as non-vocalic.

All of this implies that the representations within the articulatory gesture of the long vowels and diphthongs can be simple bimoric sequences of representations of the type already established in this section. Closing diphthongs can be given representations such as (8.30):

(8.30) a a i, u, a
     i u i, u
     RP /ai/ RP /æʊ/ Du. /æy/

if we accept, phonologically, a characterisation in which the second element of the diphthong is appropriately represented as /l/, /u/, or /y/. Phonetically, the more precise representations developed in §8.3 can be utilised, as in (8.31):
The interpretation of centring diphthongs, too, is quite straightforward. These diphthongs show simply [æ] as the second (dependent) element:

\[(8.32) \quad \text{i} \quad \text{u} \quad \text{RP} /æ/ \]

Finally, long vowels, as expected, show two occurrences of the same segmental representation:

\[(8.33) \quad \text{i} \quad \text{u}, \text{a} \quad \text{RP} /i:/ \quad \text{RP} /ə:/ \quad \text{RP} /ɔː/ \]

The flexibility afforded by the dependency system of representation allows the characterisation of long vowels and diphthongs in a natural fashion, and excludes the somewhat bizarre representations to be found in the SPE treatment.

\[(8.34) \quad /i:/ \quad \text{i} \quad /u:/ \quad \text{u} \quad \text{RP} /iː/ \quad \text{RP} /əː/ \quad \text{RP} /ɔː/ \]

(8.34) and (8.35) (from Ewen forthcoming b) give the dependency representations of the full set of RP long vowels and diphthongs:
I shall be concerned in the remainder of this chapter with the problem of the representation of consonants in the articulatory gesture. This is an area which has aroused a great deal of controversy in recent years, and there still appears to be little general agreement on some crucial issues, as we shall see. In the following sections I put forward a set of proposals which will provide at least a basis for a dependency treatment of place of articulation and associated matters.

In what follows, I do not intend to review in any great detail the proposals which have been made for feature treatments of place. However, it will be useful to consider some aspects of the two most important approaches -- the binary and the multivalued.

In the minimally componential theory of SPE, place of articulation is defined principally by two binary features [anterior] and [coronal]. [+anterior] sounds are those produced "with an obstruction that is located in front of the palato-alveolar region of the mouth", and [+coronal] sounds are those "produced with the blade of the tongue raised from its neutral position" (SPE:304). These two features yield the following distinctions among various places of articulation:

\[(8.35) /ei/ \quad /ai/ \quad /oe/ \quad /au/ \quad /ie/ \quad /ao/ \quad /ia/ \quad /ea/ \quad /oa/ \quad /eo/ \quad /au/ \]
Labials can be distinguished from labio-dentals by means of the feature [distributed] - labials ([+distributed]) being "produced with a constriction that extends for a considerable distance along the direction of the air flow", as opposed to labio-dentals ([-distributed]), which are not (SPE:312). I return in §8.8 to the relevance of [distributed] to the making of distinctions among sounds which are [+ant, +cor]; i.e. among the dentals and alveolars.

As is apparent from (8.36), body of the tongue consonants are all [-ant, -cor]. These can be distinguished from each other by the uses of the features [high], [low], and [back]; i.e. the features also used to distinguish vowels, as in (8.37) (from SPE:305):

<table>
<thead>
<tr>
<th></th>
<th>palatals</th>
<th>velars</th>
<th>uvulars</th>
<th>pharyngeals</th>
</tr>
</thead>
<tbody>
<tr>
<td>[high]</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>[low]</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>[back]</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

We can distinguish various kinds of criticism of the SPE system, of which three are particularly relevant to the following discussion. Firstly, there is evidence that has led various phonologists to propose replacing the binary feature system with a multivalued one (cf. §2.2). Secondly, there have been various suggestions that is is possible to set up hierarchies of strength in this area, such that certain places of articulation can be considered to have a 'stronger' position on the hierarchy than others with respect to their phonological behaviour. Thirdly, a number of phonologists have suggested, while retaining the binary system (at least in some cases), that certain recurrent classes cannot be adequately captured by the system given above, and so, on the natural recurrence assumption, have proposed new features to remedy this apparent defect.
In the immediately following section I return to some detailed discussion of this last area, as it is particularly relevant to the proposals I will make below; however, in the remainder of this section I will consider the first two types of criticism. First, then, let us look at proposals for a multivalued account of place of articulation.

Multivalued systems have been proposed by Ladefoged (1971, 1975) and by Williamson (1977). Perhaps the most important reason advanced for a multivalued treatment of place is that "neither the tongue nor the roof of the mouth can be divided into discrete sections" (Ladefoged 1971:37). As we saw in §2.2, this leads Ladefoged to propose a feature [articulatory place], with ten phonetic categories:

(8.38) [articulatory place] - bilabial
   labio-dental
   dental
   alveolar
   post-alveolar
   palatal
   velar
   uvular
   pharyngeal
   glottal

No language, according to Ladefoged, makes an opposition amongst more than six types. The maximal system occurs in Malayalam, and involves the nasals (Ladefoged 1971:40):

(8.39) Bilabial Dental Alveolar Post-alveolar Palatal Velar

kammi pāṇi kannī kāṇṭi kāṇṇi kāṇḍi
shortage pig Virgo link in chain boiled rice and water crushed

(Notice that the post-alveolar consonants are retroflex, and that this system contains three consonants which would be [+ant, +cor] in the sPE system - see for further discussion §8.7)

Ladefoged (1971) is non-committal as to whether [articulatory place] should be viewed as a multivalued scalar feature or as a multi-
valued independent feature in which the places of articulation are members of an unordered set; however, Ladefoged (1975) appears to adopt the former possibility – the places are given percentage values on a physical scale defined as "distance from the glottis to the first constriction of the vocal tract" (1975:208).

Various phonological arguments in favour of the multivalued interpretation of place are offered by Williamson (1977). They include the fact that "nasals are frequently homorganic with following consonants"; if a multivalued feature system is used, "only a single variable is required" to express this, while in a binary approach agreement between each feature denoting place of articulation must be indicated separately (cf. Anderson 1980). In addition, she notes that rules often "involve adjacent places of articulation".

It is not relevant to my concern here to pursue these arguments in any detail. However, we should note that Williamson interprets the feature place as a scalar feature, with "the most neutral position, 0, near the center of the scale", as in (8.40):

(8.40)  
6 upper lip (bilabial)  
5 upper teeth (labiodental)  
4 behind upper teeth (dental)  
3 alveolar ridge (alveolar)  
2 behind alveolar ridge (post-alveolar, palato-alveolar)  
1 (hard) palate (palatal)  
0 central vowel position (central)  
-1 velum (velar)  
-2 uvular area (post-velar, uvular)  
-3 back wall of the pharynx (pharyngeal)  
-4 glottis (glottal)

The assignment of values arises from Williamson's belief that "the neutral, 'unmarked' value of a feature is that which is, other things being equal, its most common value in speech" (1977:859). This theoretical viewpoint means that she must find a neutral position for [place] somewhere near the centre of the scale. This is achieved by an appeal to the notion that the tongue position for [a] is in some sense the neutral position (rather than SPE's [e] (or [ɛ])). It is not clear to me whether there is any phonological evidence to support this claim – Williamson offers one argument whose validity is not
obvious, viz:

A further reason for regarding the neutral position as central on the scale is that, of the three most common places of articulation for consonants (labial, alveolar/dental, velar), it is the velar one, adjacent to the central one, which most commonly weakens or is lost entirely.

The implication of this with respect to a scalar feature would appear to be that we should expect phonological processes to favour deletion of values towards the centre and reinforcement in some way of values towards the extremes of the scale - as far as I know, this is not the case. Indeed, Williamson herself notes an argument against this 'central' neutral value; the fact that Greenberg (1970) has observed that the expression of constraints on the occurrence of ejectives and implosives in languages of the world "must involve a linear ranking of the possible places of articulation in accordance with their distance from the glottis", such that, for example, velar ejectives are more common than labials because the constriction is closer to the glottis, with alveolar ejectives intermediate between the two. This argument, indeed, is used by both Ladefoged and Williamson as evidence for the postulation of a multivalued feature.

A multivalued feature of places cannot, in itself, characterise the cross-classificatory properties of different places, as both Ladefoged and Williamson note. Thus, such features as [apicality], [labiality], and [gravity] are proposed for the characterisation of natural recurrent groupings of (not necessarily adjacent) values of the feature [place]. I return to the motivations for each of these features in the following section.

Finally in this section, I want to consider whether there is reason to set up a hierarchy of 'strength' holding between the various places of articulation. Such a hierarchy would, of course, be expected to support the view that there is a scalar relation between the places of articulation. Proposals of this kind (particularly associated with the work of Foley - see for example 1977:25ff) assume that relations between places of articulation can be set up on the basis of the propensity of each class to undergo certain processes. Thus Foley notes that in various languages (North German, Danish, Spanish),
spirantisation of intervocalic voiced stops can occur. However, there are restrictions on how this spirantisation can be manifested. Specifically, the only possible combinations are the following:

\[(8.41)\]  
\[
a. g \rightarrow \gamma / V V / V \quad \text{(N. German)} \\
b. g, d \rightarrow \gamma, \delta / V V / V \quad \text{(Danish)} \\
c. g, d, b \rightarrow \gamma, \delta, \beta / V V / V \quad \text{(Spanish)}
\]

Thus, Foley claims, spirantisation may affect only the velars and not the others (a), or only the velars and dentals and not the labials (b), or all three places (c), but no other combination is possible. This he regards as "a manifestation of an abstract relation among phonological elements, which we will call \(\alpha\). The relation \(\alpha\) is the relative phonological strength of elements appearing phonetically as velars, dentals, and labials" (1977:28), as in (8.42):

\[(8.42)\]

\[
\begin{array}{cccc}
g & d & b \\
1 & 2 & 3
\end{array}
\]

relative phonological strength \(\alpha\)

Foley cites various pieces of evidence to support this claim. Notice that his "phonetic manifestation principles" allow the \(\alpha\) scale to be realised differently in different languages. Thus, we find (1977:49) the 'particular consistent principle': "though the phonetic manifestation of phonological elements may vary from language to language, it does not vary within any particular language". In Germanic, then, Foley claims, the manifestation of the \(\alpha\) relation is different from that in Romance languages (given in (8.42)). Because in Germanic dentals strengthen in preference to labials, they must be interpreted as stronger, thus giving (8.43) (cf. Foley 1977:50):

\[(8.43)\]

\[
\begin{array}{cccc}
g & b & d \\
1 & 2 & 3
\end{array}
\]

relative phonological strength \(\alpha\) (Germanic)

Because Foley rejects the notion that natural recurrent classes must have a phonetic basis, he is not interested in providing a pho-
netic explanation for these differences, a belief which renders him immune to the kinds of arguments that have been offered against this point of view. It has been argued in various places that there is little evidence for such positional strength hierarchies, if given a universal phonetic interpretation, in that the evidence as to which positions are stronger is so contradictory.

Thus, Lass and Anderson (1975: 5.4) show that the 'a relation' is different in different languages, and even within a single language - Hungarian shows strong velars in intervocalic position, but weak velars and labials in initial position. Katamba (1979), too, cites various processes in Luganda and other Bantu languages which appear to provide counter-evidence to the claims made by Foley. Seeing that I assume that natural recurrent classes do have a phonetic basis, then, the existence of so many (phonetic, in Foley's terms) counterexamples means that the notion that the places of articulation can be hierarchically ranked on a strength scale must be rejected. The most that can be claimed, I believe, is that for the three major positions (labial, dental/alveolar, velar), there appears to be some evidence that velars show a greater propensity to weaken than either of the other two (cf., for example, Williamson 1977 in the passage cited above, and Lass and Anderson 1975:184, who state that "the majority opinion seems to be that universally speaking it is velars that are the weakest"). Notice also that Jakobson's universals of language acquisition predict that velars are acquired later than the other two types.

I assume, then, that there is no conclusive evidence for a hierarchical relation amongst different places of articulation, and I shall not, therefore, attempt to characterise this relation in the dependency representations to be established below.

8.6 Gravity, linguality, and apicality

In §§8.6.1-8.6.3 I examine some proposals which have been made with respect to the systems outlined in the previous section. Some
involve proposals to remedy deficiencies in the binary system of SPE; specifically, the introduction of features to characterise recurrent classes not catered for there. Others are put forward by the proponents of a multivalued feature of place for much the same reason. This does not seem the appropriate place, however, to investigate these issues in great depth; rather, I intend only to look at those arguments which are relevant to the proposals which I shall make for the characterisation of place in dependency phonology, and then only in the broadest outline. For detailed discussion of the various points, the reader is referred to the sources from which the arguments are taken.

8.6.1 Gravity

One of the most important areas in which there have been proposals for the introduction of new features is the characterisation of labials and velars. We can distinguish two main types of arguments—those leading to the proposal for the introduction of an articulatory feature [labial], and those which suggest reincorporating the Jakobsonian feature [grave].

Arguments for the introduction of [labial] are put forward by S. Anderson (1971), Reighard (1972), Campbell (1974), Ladefoged (1975), and Williamson (1977). Anderson, while keeping the rest of the framework intact, suggests the introduction of "a feature [±labial], in addition to [±round], which would characterize all primary labial consonants", in view of the existence of apicalised labials in the phonological inventory of, for example, Nzema. The segment /pɛ/ in Nzema, then, would have the features [+ant, +cor, +lab, -round]. (I return in §8.8 to a more detailed discussion of secondary and double articulations.) Articulatorily, he argues, the postulation of both [labial] and [round] can be defended by the fact that there are two distinct types of labial closure; the rounding type, controlled by the orbicularis oris muscle, and the type involved in the production of (unrounded) labials such as [p], [b], and [m], i.e. raising of the lower lip, controlled by the mentalis muscle.
Reighard's arguments are based on the fact that he wishes to be able to characterise labial consonants, /w/, and round vowels as forming a natural class, for example in processes in which /w/ becomes a labial consonant, e.g. /v/. Thus, "back rounded vowels should be characterised in such a way that their labiality and their backness (i.e. velarity) is equatable with the labiality and backness of consonants". The feature [labial] does just this, he suggests.

Campbell, too, although not making any specific proposals for the introduction of new features, shows that vowels may become rounded in the environment of labial consonants, and that labial consonants may interchange with round vowels or semi-vowels.

All of these proposals, then, are concerned with providing a means of characterising a natural recurrent class which is not catered for in the SPE system. Similar proposals are made by Ladefoged (1975: 262), and by Williamson (1977). As well as the sounds [p, t, w, q] having the value [velar] for the multivalued feature of place, they are also classed as [+labial], as "there is an articulation at the lips that is of the same magnitude as an articulation elsewhere in the vocal tract".

The other group of proposals in this area concern the reintroduction of the Jakobsonian feature [grave]; i.e. "the predominance of one side of the significant part of the spectrum over the other" (Jakobson et al 1952:29). Grave sounds, then, show predominance of the lower side of the spectrum. The arguments for the use of this feature concern primarily the fact that labials and velars form a recurrent class in languages. Thus, Hyman (1973) records changes in which velars become labials historically, and in which front vowels become back before labials and velars. The Chomsky and Halle features are not appropriate for the characterisation of this natural class, although in languages which have phonologically only labials, dentals, and velars, the class can be unambiguously defined as [-coronal]. As Lass points out (1976:206ff), this is a 'negatively' defined class: it is not clear why the fact that there is no raising of the blade of the tongue involved in these sounds should make them a natural class (no-
tice, too, that all vowels are [-coronal]). It in no way explains the fact that this is a natural recurrent class. Even worse, in a language which has phonemic palatals, the set of labials and velars cannot be shown to form a natural class at all, as palatals are also [-coronal]. The only possible characterisation of the recurrent class is:

(8.44) \[
\begin{align*}
\{ & \text{+ant} \\
\{ & \text{-cor} \\
\{ & [+\text{back}] \\
\end{align*}
\]

Similar arguments are advanced by other writers, for example Davidsen-Nielsen and Ørum (1978), who suggest that certain assimilation processes in Old English and Danish involve gravity, and Strøjer (1979), who characterises the class of consonants triggering OE Breaking (cf. (1.19)) as being [grave]. In the alternative multivalued minimally componential systems, Ladefoged (1971, 1975) also proposes a feature [gravity] to account for the "acoustic (and hence) auditory similarities between corresponding sounds made in the labial and velar regions", such as [p] and [k], [f] and [x] (cf. Williamson 1977).

I do not intend to pursue these arguments any further; I take it that there is sufficient evidence of this sort to indicate the need for a feature, or component, of gravity. It will be recalled, indeed, that the component [u] proposed above for the characterisation of vowels was also defined as 'gravity', and in §8.7 I will show how this component can be incorporated into the representations characterising place of articulation. Further, I will suggest that it is probably not necessary within the dependency system to have separate components of 'gravity' and 'labiality'. In the meantime, however, I turn to another set of proposals arising from the existence of recurrent classes undefined by the Chomsky and Halle system.

8.6.2 Linguality

Lass (1976:ch.6) surveys a range of sixteen processes from the history of English and from Modern English "involving considerable
recurrence and similarity”. These processes involve fronting, high vowel epenthesis, and, principally, raising. He suggests that there is a recurrent grouping of segments triggering these processes, consisting of high front vowels, dental, alveolar, palatal, and velar consonants, and possibly high back vowels like [u]. This, he argues, is a class that cannot be characterised in the SPE system; crucially because dentals (and alveolars) differ in their values for the features [anterior], [coronal], and [high] compared with velars, palatals, and high vowels (both front and back).

Lass's solution to the problem of characterising this natural class is the introduction of a feature [lingual], which he defines as follows (1976:187):

Horizontally speaking, all predentals and postvelars are [-lingual], and dentals, palatals, and velars are [+lingual] (as are high vowels ...).

Because uvulars are not produced with primary activity of the blade or body of the tongue, they are not [+lingual]; thus, [+lingual] sounds are those produced with the blade or body of the tongue as a primary active articulator. High vowels are [+lingual] because they are unique among the vowels "in that they alone might be said to have 'homorganic' consonants" (1976:193). He concludes that the various processes can all be characterised as involving an assimilation towards linguality:

Nonlingual vowels become lingual before linguals (or after them), the diphthongizations insert the appropriate [+ling] vowels in environments marked the same way, and so on.

We should notice that the feature [lingual] has an unusual status in the model proposed by Lass. It is not proposed as a replacement for the normal features characterising place of articulation, but rather as a 'second-order' feature, i.e. a feature which is never distinctive (in, for example, lexical specifications in a language), but which is nevertheless 'classificatory' in the sense of defining natural recurrent classes. That is, segments are never distinguished from each other purely by a difference in value for the feature [lin-gual], but it may be required in the characterisation of processes in
which just those segments marked as [+lingual] in a language trigger a particular change.

The feature [lingual] (as a primary feature, rather than as a second-order feature) has also been proposed by Brown (1972) in her description of Lumasaaba. [+lingual] sounds are those in which "the active articulator is the tongue". This feature distinguishes alveolars and velars from labials in Lumasaaba.

8.6.3 Apicality

As noted above, the sPE feature [distributed] is used to make certain distinctions in the dental and alveolar region. Thus (sPE: 312) laminals are [+distributed] (involving a constriction that extends for a considerable distance along the direction of the air flow) as opposed to apicals, which are [-distributed]. Similarly, retroflex sounds are [-distributed], while non-retroflex sounds are [+distributed]. Thus, [ʃ] [+distributed] can be opposed to retroflex [ʂ] [-distributed], where the constriction is relatively short. Notice, too, that this feature can also be used to distinguish alveolar fricatives, e.g. [s] [+distributed], from interdental fricatives, e.g. [θ] [-distributed].

This feature has been criticised on various grounds; notably that it obscures the fact that the distinction between, for example, [s] and [θ] is primarily the place of articulation. Further, Ladefoged notes that the claim which Chomsky and Halle make with respect to laminal and apical articulations, i.e. that no language makes an opposition between two apical articulations in the dental/alveolar (i.e. [+ant, +cor]) region, is controverted by the Malayalam data in (8.39), in which the dental, alveolar, and retroflex nasals are all apical. This leads Ladefoged (1971) to propose a feature [apicality]; tip of the tongue consonants have the value 0, and blade of the tongue sounds the value 1. Retroflex consonants are characterised as having the value [retroflex] of the [place] feature.

Williamson (1977) proposes an extension of the [apicality] fea-
ture, such that retroflex sounds are involved, as in (8.45):

\[(8.45) \quad \begin{align*}
1 & \text{ blade of tongue as articulator} & \text{(laminal)} \\
0 & \text{ tip of tongue as articulator} & \text{(apical)} \\
-1 & \text{ underside of tongue as articulator} & \text{(retroflex)}
\end{align*} \]

The argument against characterising retroflex consonants as one of the values of the [place] feature is that retroflex sounds differ not in the passive articulator (which is often the same as for non-retroflex post-alveolar sounds), but in the active articulator; in the same way as laminal and apical sounds may have the same passive articulator (notice, however, that the difference between laminal and apical sounds appears never to be phonologically contrastive in itself).

Finally, Brown (1972), working within a binary feature system, also uses a feature [apical] ([+apical] sounds being those in which "the active articulator is the point or blade of the tongue") to distinguish the same class as \textit{sPE} [+coronal].

I have considered these matters only very briefly, but as will be seen below, I wish to incorporate some of these suggestions into the dependency representations for place of articulation which I shall offer in the following section.

8.7 The dependency representation of place

Let us see, then, how these various facts about natural recurrent classes and their characterisation can be incorporated into a system of representation using dependency components. I consider first the representation of what might be termed the three basic places of articulation: labials, dentals/alveolars, and velars.

In §8.1 I noted that the component \(|u|\), used in the characterisation of back vowels, could be defined in the same way as the Jakobsonian feature [grave]; i.e. the more predominant the \(|u|\), the greater the predominance of the lower part of the spectrum. It thus seems reasonable to assume that in the representation of labials and velars,
the component [u] appears, thus enabling their status as a natural class to be characterised, together with the class discussed by Reighard, that of labial consonants, [w], and round vowels ([w] will presumably have the same representation in the articulatory gesture as [u], differing only in its specification in the categorial gesture - \{[V \neq V,C]\} vs. \{[V]\}. All these segments, then, contain [u] in the articulatory gesture.

I suggest that velars are distinguished from labials by the presence in their representation of a component of *linguality* [1], comparable to Lass's and Brown's [lingual]. Segments displaying this component in their representations, then, are produced with the blade or body of the tongue as an active articulator. However, I do not interpret this component as some sort of 'second-order' or 'cover' feature. Rather, I suggest, this component has the same status as [u], to give the following characterisations for the three main places of articulation:

(8.46) \{[u]\} \quad \{[1]\} \quad \{[1,u]\}
labials dentals/ alveolars velars

In a phonological system in which the only oppositions among places of articulation are the three in (8.46), these representations are adequate for its characterisation. Thus, labials are characterised as containing [u] alone, while dentals/alveolars contain only the linguality component. Velars, however, contain both components, and as such, can be shown to form a natural recurrent class with both labials and dentals. Notice, too, that as the gravity component alone characterises labials, there is no need to have a separate labiality component.

A further advantage of this characterisation is that velars have a more complex representation than the other positional classes. As noted in §8.5, what evidence there is appears to suggest that velars are phonologically more complex than labials and dentals; the more complex representations for velars in (8.46), then, appropriately reflect this.
For the moment, I postpone the question of whether \(|l|\) is also required in the characterisation of high vowels, as is suggested by Lass for [lingual]; it may well be that these vowels redundantly show \(|l|\) in their representations, thus allowing the characterisation of the linguality assimilation processes discussed above. For high vowels, though, it does not seem likely that \(|l|\) will be a primary component; rather, if it is required, it will be a 'second-order' component.

A system containing phonemic palatals in addition to the positional types in (8.46) is also simply characterised. Palatals show a representation of the same type as that for velars:

\[(8.47) \{[l,l]\}\]

palatals

Notice that none of the representations so far developed need show dependency relations between the components; rather, palatals and velars can show simple combinations of \(|l|\) with, respectively, \(|i|\) and \(|u|\), i.e., strictly, \{[l,i]\} and \{[l,u]\}.

I turn now to the dental/alveolar region. As we have seen, various kinds of opposition can be made within this area. Consider first of all the so-called positional class of post-alveolars. Lade-foged (1971:40) notes that there is probably no reason to distinguish these consonants phonologically from palatals - all languages which use both these places having stops in one position and affricates in the other. Similarly, Lass (1976:188-189) claims that palato-alveolars are not a true positional class, even phonetically. Rather, as their name suggests, they are palatalised alveolars, i.e. alveolars with a secondary palatal articulation. I consider these sounds, therefore, along with other double and secondary articulations, in the following section.

However, this is not true of the distinction between laminal, apical, and retroflex segments, which, as noted above, again do not represent different positional classes, but rather different uses of the active articulator. Languages do not appear to make oppositions
amongst more than two of these classes; thus, Ladefoged (1971:39) gives the following data:

(8.48) apical laminal apical laminal apical
dental denti- alveolar alveolar retroflex
alveolar

Temne ḟon ḟor
descend farms

Isoko òtú òtú
touse gang

Ewe ëdá ëdá
he throws she laid

I propose the introduction of a component of apicality \(|t|\), whose characterisation will be similar to that of Williamson's multivalued feature [apicality]. That is to say, three possible configurations can be represented, as in (8.49):

(8.49) \{|l |\} \{|l |\} \{|t |\}
    laminals apicals retroflexes
    (sub-laminals)

It will be noted that retroflexes show |t| in governing position, whereas they had a negative value for Williamson's [apicality] feature. I believe that (8.49) more successfully shows the relation of the tip of the tongue in the segment-types in (8.48) to the role of the blade of the tongue. For the laminals, the blade is more 'important' than the tip, and hence governs; for the apicals the tip is more important and the blade less important; and for retroflexes, only the tip and underblade can make actual contact with the passive articulator because of the nature of the configuration of the tongue.

However, as the data in (8.48) indicates, no language makes a three-way phonological opposition amongst these segment-types; although all occur phonetically. Rather, only two-way oppositions are found. In all of the cases in (8.48), then, the two-way oppositions can be represented as (8.50):
In a language making an opposition between an apical dental and a retroflex, the apical would have the (phonological) representation \( \{t \neq \text{t}\} \), while the retroflex would show the reverse relationship. Thus, as in the case of the characterisation of vowels above, it is the function of a particular segment-type in the phonological system which determines its representation; thus the same phonetic type (apical dentals) may have different representations in different languages.

Notice that the relative complexity of systems involving phonological oppositions in this area is reflected both by the need to introduce the component \(|t|\) in phonological representations, and in the introduction of dependency relations between components. Further, \(|t|\) never occurs alone, but only in combination with another component.

This component might also be used to characterise the difference between various other segments which are distinguished by means of the feature \([\text{distributed}]\) in the SPE model. Thus, apical [t] might be distinguished from laminal [s] and from sub-laminal (retroflex) [\(\ddot{s}\)] by the relative prominence of \(|t|\) (while palato-alveolar [\(\dddot{s}\)], as noted above, will be treated as an alveolar with secondary palatalisation). However, although we have seen that the component \(|t|\) can distinguish laminals from apicals, and alveolars from dentals in those languages which do not make an opposition between laminal alveolars and laminal dentals, or between apical alveolars and apical dentals, this is not necessarily the ideal way of characterising the opposition between alveolars and dentals in all languages. As Ladefoged (1971:39) notes:

None of the languages that I have heard myself uses a contrast between an apical and a laminal articulation.
at the same place. . . . The apical-laminal distinctions could be said to function simply as intensifiers of the small differences in the place of articulation. Further, as we have seen, there are languages in which apical dentals contrast with apical alveolars.

It seems preferable, then, to characterise the alveolar/dental distinction directly, i.e. by means of a component concerned with the passive articulator, rather than with the active articulator. This does not mean, however, that the laminal/apical distinction is not required. Clearly, it is necessary for the characterisation of the opposition between retroflexes and non-retroflexes, and it is also needed at the phonetic level to specify whether a particular sound — e.g. English /d/ — is realised as laminal or apical.

The appropriate way of representing the opposition directly is by means of a component of dentality, represented as, let us say, [d]. This component will be required in any case to distinguish labials from labio-dentals, phonetically in most languages, but phonologically in, for example, Ewe, which shows an opposition between bilabial and labio-dental fricatives (Ladefoged 1971:38):

(8.51) ëɓè ‘the Ewe language’ ëvè ‘two’
èɓá ‘he polished’ èfá ‘he was cold’
èɓli ‘mushroom’ èvló ‘he is evil’
èɓlè ‘he bought’ èflé ‘he split off’

This opposition will be represented as:

(8.52) {u} {u,d}
labials labio-dentals

A language employing this opposition is shown to have a more complex system than one which does not, because of the presence of [d]. Again, [d], like [t], always occurs in combination, never alone. In languages such as English, [d] will be required only in the phonetic realisation rules; phonologically, both bilabial stops and labio-dental fricatives will be characterised simply as {u}.
The component \(|d|\), then, can also be used to make the distinction between dentals and alveolars in languages where this phonological opposition is required. Thus, Temne /t/ vs. /t/, and English /θ/ vs. /s/ might both be characterised as follows:

\[(8.53) \{ |1,d| \} \quad \{ |1| \} \]

dentals \quad \text{alveolars}

Again, relative system-complexity is characterised by the need to have \(|d|\) in phonological representations; while the relative complexity of dental fricatives as a class is shown by the more complex representation for /θ/ than for /s/.

What we have here, then, is a case of two parameters - dental articulation vs. alveolar articulation, and apicality vs. laminality - which are phonetically independent, and which must therefore both be characterised in our system of representation. The decision on whether to characterise a particular opposition by means of \(|d|\) or by means of \(|t|\) depends on the phonologist's interpretation of the data in the language in question, but it seems likely that, by and large, the direct representation of the dental/alveolar distinction by the use of \(|d|\) is more appropriate. However, there are cases in which both are required. In the Malayalam data in (8.39), we find dentals, alveolars, and retroflexes, all of which are apical, according to Ladefoged. The high degree of complexity of the system, which also has bilabials, palatals, and velars, is shown in (8.54):

\[(8.54) \quad u \quad \underline{1,d} \quad \underline{1} \quad t \quad \underline{1;1} \quad \underline{1;u} \]

\[
\begin{array}{ccccccc}
/m/ & /d/ & /n/ & /n/ & /n/ & /n/ & /n/ \\
\end{array}
\]

where both \(|d|\) and \(|t|\) are required, as well as \(|1|\), \(|i|\), and \(|u|\).

(Notice that, phonetically, \(|t|\) will also be present in the representation of (apical) /\text{n}/, which will have the characterisation \{ |1,d,t| \}; cf. (apical) alveolar /\text{n}/, which has \{ |1,t| \}.)

As far as the characterisation of place of articulation is con-
cerned, perhaps the most important remaining difficulties concern the characterisation of uvulars and pharyngeals. Chomsky and Halle, as we saw in (8.37), characterise uvulars as [-high, -low, +back], and pharyngeals as [-high, +low, +back]. In other words, uvulars have the same 'body of the tongue' feature-values as [o], and pharyngeals the same as [a].

For pharyngeals, especially, this feature assignment has been criticised, on the grounds that:
the front-back distinction is concerned with the configuration of the upper surface of the tongue, and this can have nothing to do with pharyngealization, which involves an approximation of the rear or root of the tongue to the pharyngeal wall. (Sommerstein 1977:102).

This point is taken up by Lass and Anderson (1975:18), with respect to the distinction between uvulars and pharyngeals. They claim that the distinction is not of degree of lowness, as the Chomsky and Halle features would suggest, but of backness, caused by the tongue-root retraction associated with pharyngeals. They note further that the vowels cognate to uvulars are not mid vowels, such as [œ], as would be expected from the SPE features, but low back vowels. This leads them to characterise uvulars as [+low].

A similar analysis is offered by Catford (1977:160-163), who distinguishes dorso-uvulars (produced with the surface of the tongue) from two types of pharyngeals; faucal, produced without use of the tongue, and linguo-, produced with retraction of the root of the tongue.

Thus, we might argue that uvulars should be characterised as containing both [a], the lowness component, and [l], the 'linguality' component, as in (8.55):

(8.55) \{[l,a]\}

uvulars

However, it will be recalled that uvulars are excluded from the set of segments having a plus-value for Lass's [lingual] feature, be-
cause they do not trigger the linguality assimilation process, and because "uvulars and pharyngeals, even though the tongue is involved in them, are not made with primary activity of either the blade or body" (1976:188). It is not, however, clear that this is the case, at least as far as uvulars are concerned, given Catford's account of these sounds. A second problem which arises is that uvulars should apparently be considered to be grave, and therefore to have the \(|u|\) component in their representation.

It is not clear how these various possibilities for the representation of uvulars should be evaluated - i.e. which of \(|l|\), \(|a|\), \(|u|\) their representations should contain. This uncertainty arises partly from the fact that there is less information on the status of these segments with respect to their behaviour in natural recurrent processes, information which might lead to a more definite claim than the one made here, i.e. that uvulars should be represented as:

\[
(8.56) \{l,u,a\}
\]

uvulars

As far as the representation of pharyngeals is concerned, \(|l|\) can in any case not be used. It may well be, however, that \(|a|\) is required (at least phonetically), but it is not clear whether \(|u|\) will also be needed. Although some phonologists have interpreted pharyngeals as grave (see, for example, Davidsen-Nielsen and Ørum 1978:210, who consider Danish \([u]\), \([o]\), and \([a]\) to be grave and pharyngeal), Ladefoged (1971:102) states that "pharyngeal sounds are not grave". As far as \(|a|\) is concerned, Ladefoged (1971:80) suggests that \([\delta]\) (a voiceless pharyngeal fricative) and \([\alpha]\) share the feature pharyngeal, back, and low; notice, too, that Davidsen-Nielsen and Ørum characterise \([\alpha]\) as pharyngeal.

However, \(|a|\) (with or without \(|u|\)) is not in itself sufficient for the characterisation of pharyngeals, in that such a representation would, for example, suggest a high degree of sonorancy associated with these segments, which does not appear to be the case. Rather, it seems that pharyngeals must be characterised more directly (cf.}
the case of dentality above); that is, we need a component whose presence defines a pharyngeal articulation. This is a proposal which can be found in various distinctive feature treatments.

The relevant phonetic property appears to be width of the pharynx, which in turn is controlled by retraction of the root of the tongue (Lindau et al 1971). Thus, Williamson (1977) and Lindau (1978) have a feature [expanded], whose phonetic correlate is the size of the pharynx. I suggest, then, that pharyngeals are characterised by a component |r| retracted tongue root (and consequent pharyngeal narrowing), giving the possible representation in (8.57):

(8.57) \{ |r,(u),a| \}

pharyngeals

Again, further evidence is required to determine the appropriate characterisation of pharyngeals at different levels in the phonology. Clearly, \{|r|\} alone will be sufficient to distinguish pharyngeals at the lexical level, but it may well be that |a| (and perhaps |u|) may function as 'second-order' components in particular phonological processes. I return in §8.8 to the characterisation of pharyngealisation as a secondary articulation.

A similar mechanism is also used in a rather different area, that of vowel harmony in a number of languages. Lindau (1978:550) notes that many Niger-Congo and Nilo-Saharan languages show such systems, in which the vowels of the language divide into two sets, the members of each of which must harmonise within a morpheme (i.e. occur only with other members of the same set). These two sets differ in the "size of the pharynx", as controlled by variations in the positions of the root of the tongue and the larynx. (8.58) shows the segments occurring in the Akyem dialect of Akan:

(8.58) Set 1                      Set 2
    \{ i u e o \}                \{ i o e o \}
    a ^
Various features have been proposed for the characterisation of the difference between the two sets. Chomsky and Halle (1968:314-315) have [covered] - [+covered] sounds having a narrower and tensed pharynx and raised larynx; Ladefoged (1971:75) has [tension] ("the degree to which the root of the tongue is pulled forward so that the tongue is bunched up lengthways"); Ladefoged (1975:266) has [wide] (i.e. width of the pharynx); while we have already seen that Lindau (1978) has [expanded] (i.e. size of the pharynx). Halle and Stevens (1969) have simply the feature [advanced tongue root] (cf. Lindau et al 1971) - a proposal which dates back to Stewart (1967:196ff).

Clearly, the same mechanism is involved in these vowel harmony processes as in pharyngealisation. Lindau notes that the contrast is made in West African languages by the tongue root deviating in opposite directions from the zero value for the feature. In dependency terms, then, the difference between the two sets participating in vowel harmony processes can be characterised as:

\[(8.59) \{i \neq r\} \forall \{r \neq i\}\]

advanced tongue root non-advanced tongue root

I suggest that the dependency representations in (8.59) are appropriate, in that what is involved is an equipollent relationship between the two sets; there seems to be no reason to postulate that one is phonologically more complex than the other. The complexity of such systems, however, is shown by the presence of \(|r|\) in phonological representations. Contrast this with the treatment of pharyngeal consonants above; the opposition between pharyngeal and non-pharyngeal consonants is, I believe, phonologically privative. Thus, pharyngeal consonants are taken to be marked by the presence of the \(|r|\) component. This, then, explains why the component is defined as involving retraction, rather than advancement, of the tongue root.

Notice, however, that Stewart (1967:193-194, 202) claims that there is also a markedness relation holding between the two sets of vowels in the Akan vowel harmony system. On grounds of frequency of occurrence, and assimilation of non-advanced tongue root vowels to
advanced tongue root vowels, he claims that the non-advanced tongue root set should be treated as unmarked. There seems, though, to be no reason for assuming that, phonetically, the advanced tongue root series displays a property that the non-advanced tongue root series does not. Thus, Lindau (1978:551) notes:

The Set I vowels /i eu o/ are produced with a relatively large pharynx, by advancing the root of the tongue beyond a 'normal' position for the vowel, and by lowering the larynx. The relatively small pharynx of the Set 2 vowels /ɛ ɔ ɔ/ is produced by retracting the root of the tongue and by raising the larynx.

This strongly suggests an equipollent interpretation of the opposition between the two sets; notice, too, that in the case of vowel harmony systems we have an opposition between two apparently equivalent sets (both containing a set of vowels), while in the case of pharyngeal consonants, we have an opposition between a very restricted set of segments and all other consonants in the language in which they occur.

However that may be, the various phonetic possibilities display a scalar relationship, as in (8.60):

(8.60) \( \{x \nsim r\} \quad \{x \nsim r\} \quad \{r \nsim x\} \)

advanced 'neutral' retracted

I have made a number of proposals which allow for the expression of a large range of possibilities with respect to place of articulation and the recurrent classes operating within this area. It still remains, however, to consider the questions of double and secondary articulations, and of nasality and laterality.

8.8 Secondary and double articulations

Phonetically, at least, we can distinguish two types of co-articulation - 'co-ordinate (or double) articulation', and 'secondary articulation' (Catford 1977:188). In the case of double articulation, "the two articulations are of the same stricture-type", while in 'primary' and 'secondary' co-articulation, the secondary articulation is of lower strictureal rank than the primary articulation (i.e. it has a
more open degree of stricture). I consider first the representation of secondary articulations.

Ladefoged (1971:62) distinguishes four types of secondary articulations, as in (8.61):

\[(8.61)\]

<table>
<thead>
<tr>
<th>Secondary Articulation</th>
<th>Representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labialization</td>
<td>Added lip-rounding or protrusion</td>
</tr>
<tr>
<td>Palatalization</td>
<td>Raising of the front of the tongue</td>
</tr>
<tr>
<td>Velarization</td>
<td>Raising of the back of the tongue</td>
</tr>
<tr>
<td>Pharyngealization</td>
<td>Retracting of the root of the tongue</td>
</tr>
</tbody>
</table>

The various approaches to the representation of such secondary articulations can be summarised as follows. For Jakobson et al., secondary articulations fall under the various acoustic features. Thus labialisation and pharyngealisation are both characterised by the feature flat vs. plain, as both involve a downward shift of a set of formants. "These two processes do not occur within one language" (1952:31), and are thus to be treated as manifestations of the same opposition. In SPE, palatalisation, velarisation, and pharyngealisation are characterised as involving the assignment of a '+'-value for at least one of the tongue-body features ([high], [low], or [back]) to a non-tongue-body consonant (i.e. one which is [+ant] and/or [+cor]). The tongue-body features for a secondary articulation are the same as those for the corresponding primary articulation, as shown in (8.62):

\[(8.62)\]

<table>
<thead>
<tr>
<th>Secondary Articulation</th>
<th>Palatals</th>
<th>Palatalised Dentals</th>
<th>Velars</th>
<th>Velarised Dentals</th>
<th>Pharyngeals</th>
<th>Pharyngealised Dentals</th>
</tr>
</thead>
<tbody>
<tr>
<td>anterior</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>coronal</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>high</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>low</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>back</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

Chomsky and Halle (SPE:307) claim as advantages for their account the fact that (8.62) shows why palatalisation, velarisation, and pharyngealisation do not occur with tongue-body (i.e. [-ant, -cor]) consonants, that it show that primary and secondary articula-
tions at the same place of articulation have the same tongue-body features, and that the secondary articulations are mutually exclusive. Notice further that labialisation is treated as the addition of [+round] to the primary articulation.

Ladefoged (1971) considers consonants with secondary articulations to have added vowel-like characteristics. Thus, these consonants have values for [backness] and [height] as well as [articulatory place], to give (8.63) (1971:80):

\[(8.63) \quad k^J \quad \pm (l^w) \quad z^D\]

<table>
<thead>
<tr>
<th>Articulatory Place</th>
<th>Backness</th>
<th>Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>velar</td>
<td>front</td>
<td>high</td>
</tr>
<tr>
<td>alveolar</td>
<td>back</td>
<td>high</td>
</tr>
<tr>
<td>alveolar</td>
<td></td>
<td>low</td>
</tr>
</tbody>
</table>

Notice that Ladefoged wants to allow for [k^J] (secondary palatalisation of a tongue-body consonant), which represents the "palatalisation of a velar consonant before a front vowel". Labialisation is handled by the addition of the [+round] feature-value to the [place] feature; thus [b^w], with the values [bilabial, +grave, +round], is distinguished from [b] only in the value for [round].

Williamson (1977:857-858) has a rather different solution to the problem of the representation of such segments. She notes that in the production of consonants with secondary articulation, "the two articulations cannot be described as exactly simultaneous", and proposes that they should be assigned two successive values for the relevant features, i.e. [stricture] and [place], as in (8.64):

\[(8.64) \quad [b^w] \quad [b^J] \quad [b^w] \quad [b^D]\]

<table>
<thead>
<tr>
<th>Stricture</th>
<th>Place</th>
</tr>
</thead>
<tbody>
<tr>
<td>2/0</td>
<td>6/6</td>
</tr>
<tr>
<td>2/0</td>
<td>6/1</td>
</tr>
<tr>
<td>2/0</td>
<td>6/-1</td>
</tr>
<tr>
<td>2/0</td>
<td>6/-3</td>
</tr>
</tbody>
</table>


Whatever the phonetic merits of such a proposal, its phonological appropriateness seems dubious. There seems to be no particular
reason to suggest that what is involved here is phonologically a stop followed by an approximant; indeed it would have unfortunate repercussions for the notion that the order of segments within the syllable can be predicted according to a hierarchy of sonority or relative prominence—syllable-final consonants with secondary articulation would violate this hierarchy in this proposal. In addition, the representations in (8.64) fail to show that either phase of the consonant is primary, i.e. they do not show which is the primary and which the secondary articulation. Finally, I shall show below that Williamson's proposal for the characterisation of double articulations involves a rather similar strategy, but one in which no sequencing is involved; however, the distinction between the two types of articulation (double and secondary) can only be represented by means which are formally rather unsatisfactory.

In the dependency model, secondary articulations can be given a rather obvious interpretation. I suggest that consonants showing secondary articulation are, at least phonologically, single segments, in which the components characterising the place of the secondary articulation are subjoined to those characterising the place of the primary articulation. Thus, palatalisation, velarisation, and pharyngealisation might be represented as (8.65):

(8.65) \[
\{ |x \simeq 1, i| \} \quad \{ |x \simeq 1, u| \} \quad \{ |x \simeq r| \}
\]

palatalised velarised pharyngealised consonants consonants consonants

Palato-alveolars, I argued above (following Lass 1976), are in fact alveolars with secondary palatalisation. As such, then, they will have the representation in (8.66):

(8.66) \[
\{ |1 \simeq 1, i| \}
\]

palato-alveolars

It seems reasonable to claim, however, that in secondary palatalisation, the dependent |1| can be suppressed phonologically, in that only the secondary articulation involving |1| can be palatalisation; contrast this with velarisation, in which |1| cannot be suppres-
sed, in that the presence of dependent $|u|$ may also denote labialisation, as in (8.67):

$$\text{(8.67)} \ \{x \overset{	ext{u}}{\Rightarrow} u\}$$

labialised consonants

As noted above, it does not seem necessary to introduce a distinct component of labiality in addition to $|u|$. If this is so, the distinction between rounded and unrounded labials will most appropriately be represented as (8.68):

$$\text{(8.68)} \ \{u\} \quad \{u \overset{\text{u}}{\Rightarrow} u\}$$

labials rounded labials

in which we see that the representation for the rounded labials involves two occurrences of the same component, in an asymmetrical relation. Thus these segments are characterised as involving an extra degree of gravity as compared with their unrounded counterparts.

Other less common secondary articulations such as labio-dentalisation and uvularisation can be characterised in the same manner, by subjunction of the appropriate representations to that of the primary articulation.

The characterisation of double articulations has proved problematical to proponents of binary feature theories. Jakobson et al (1952:22-23) consider double stops to be "but special forms of consonant clusters". Apparently, then they are to be treated as two segments, a position which runs into the same problems as Williamson's interpretation of secondary articulations, namely that it obscures the fact that the two articulations are simultaneous, and function phonologically as a single segment.

Chomsky and Halle (SPE:311) consider the problem of labio-velars (or, more correctly, labial-velars), i.e. the sounds represented as <kp> in various languages, and notice that such sounds have to be characterised either as labials with extreme velarisation or as velars with extreme rounding, as in (8.69):
In other words, in the minimally binary framework double articulations are characterised in the same way as secondary articulations, and the choice between the two possibilities in (8.69) depends on phonological, not phonetic evidence. This viewpoint is defended extensively by S. Anderson (1976b), who argues that phonetically identical labial-velars may be interpreted as labials (with superimposed velarisation) or as velars (with superimposed labialisation) according to purely phonological considerations. The arguments which he adduces are principally distributional, but he also cites evidence from various phonological processes in which, for example, labial-velar [w] is replaced in some languages by [g] (and hence must be treated as a velar), and in other languages by a labial obstruent (and hence is a labial). This interpretation, however, forces the treatment of one of the articulations of a double articulation as primary, even though there may not be any phonological evidence to support this in a particular case. Ohala (1979), as part of an attack on the emphasis put on structuralist considerations in an approach like Anderson's, cites some phonological evidence which shows that the treatment of either the labial or velar slot as primary cannot be maintained. He concludes that the tendency for labial-velars to behave as labials in some environments and as velars in others is due to physical phonetic causes arising from the different nature of the two constrictions. In addition, it can be observed that at the phonetic level we need to be able to specify that the two degrees of stricture are equivalent, and so it seems appropriate to have some mechanism in the phonological framework whereby double articulations can be directly specified.

This interpretation is apparent in the multivalued framework of Ladefoged and Williamson. Ladefoged (1971), as we saw in (2.12), has simply two additional values for the feature [place], i.e. [labial-velar] and [labial-alveolar], while Ladefoged (1975) abandons this
position, because of the introduction of the feature [labial]. Thus, $[\kappa p, \ell p, w, u]$ have the value [velar] for the [place] feature, and are also [+labial]. Williamson, however, introduces the notion of labial-velars having two simultaneous specifications for the feature [place], as in (8.70):

$$
\begin{array}{ccc}
\text{stricture} & \text{place} \\
[\kappa p] & (-1/6) \\
[w] & (-1/6)
\end{array}
$$

Notice that Williamson’s representations for double articulations, in which the two specifications for [place] are simultaneous, and for secondary articulations, in which the two specifications are successive, differ only (as far as [place] is concerned) in the presence of brackets around the values for the double articulation. It is difficult to see this as anything other than a notational diacritic.

The greater variety of structural properties available within dependency theory means that these problems can be simply overcome. Given the existence of the relation of mutual dependency, together with the fact that nodes showing mutually dependency need not be sequentially distinct, double articulations can be simply characterised:

$$
\begin{array}{ccc}
\text{stricture} & \text{place} \\
[1, u]:[u] & (-1/6) \\
[\ell c] & (-1/6)
\end{array}
$$

Thus, double articulations are interpreted in a very traditional way, in which the notion of the two articulations having the same strucrural rank is represented by their shared categorial specification, together with the fact that their articulatory specifications show the same degree of dependency.

8.9 Laterals and nasals

The treatment of laterals and nasals is quite straightforward. As in nearly all other systems of representation, I propose compo-
ents of laterality $|\lambda|$, and of nasality $|n|$. In sounds containing the component $|\lambda|$ the sides of the tongue are lowered, and in those containing $|n|$, the velum is lowered, thus allowing air to escape through the nasal cavity. The various liquids, then, will have the following representations in the articulatory gesture:

\[
\begin{align*}
(8.72) \quad & \{1\} \quad \{1,\lambda\} \quad \{1,n\} \\
\text{non-lateral} & \quad \text{lateral} & \quad \text{nasal} \\
\text{alveolar} & \quad \text{alveolars} & \quad \text{alveolars}
\end{align*}
\]

Laterals, then, are distinguished from other liquids by the addition of $|\lambda|$.

It will be noted that there are now two means of characterising nasals uniquely - by the presence of the representation $\{V \not= C\}$ in the categorial gesture, and by the presence of $|n|$ in the articulatory gesture. It may be asked why such a double characterisation is necessary. Clearly, there are two distinct phonetic parameters involved, parameters which determine the behaviour of nasal consonants with respect to natural recurrence. Nasal consonants, by virtue of their acoustic properties, form a natural class with the other sonorant consonants, and as such share certain characteristics in the representations of the categorial gesture. However, nasal consonants also have to be characterised as forming a natural class with nasalised consonants and nasal vowels (segments which may have quite different categorial specifications); their recurrence is determined by the presence of a lowered velum, i.e. by the component $|n|$. Thus (8.73) shows the representations for various nasal(ised) segments:

\[
\begin{align*}
(8.73) \quad & \begin{bmatrix} 1,1,n \end{bmatrix} \quad \begin{bmatrix} 1,n \end{bmatrix} \quad \begin{bmatrix} 1,n \end{bmatrix} \\
\begin{bmatrix} V & \not= C \end{bmatrix} & \begin{bmatrix} V \end{bmatrix} & \begin{bmatrix} V,C & \not= V \end{bmatrix} \\
[n] & [I] & [z]
\end{align*}
\]

As noted in §7.4.3, the nasality component must be used in characterising the various 'nasal spreading' processes discussed there. In Apinaye, for example, processes such as $/\tilde{V}bV/ \rightarrow [\tilde{V}m\tilde{b}V]$ and $/\tilde{V}bdV/ \rightarrow [\tilde{V}m\tilde{d}V]$ can be characterised simply as the spreading of the nasality.
component from the vowel to a contiguous consonant (cluster); if it is a single consonant, it will 'split' to become prenasalised, to give (8.74), while if it is a cluster, the first element only will take the nasality component, as in (8.75):

(8.74)

\[
\begin{array}{c}
\text{V} \\
\text{n} \\
\text{V;C} \\
\text{u,n} \\
\text{C;V} \\
\text{u}
\end{array}
\]

(8.75)

\[
\begin{array}{c}
\text{V} \\
\text{n} \\
\text{V;C} \\
\text{u,n} \\
\text{C;V} \\
\text{u}
\end{array}
\]

(in which the appropriate articulatory representation is shown below the corresponding categorial representation).

Notice that there is evidence to suggest that there is at least one language in which \( |n| \) shows dependency relations with other components, although usually (as in (8.73)) it occurs only in simple combination. Both Ladefoged (1971:35) and Catford (1977:139) cite the case of Chinantec, in which the following minimal set is found:

(8.76) ha 'so, such' M. '(he) spreads hã 'foam, froth' open'

In (8.76) we see that two different degrees of nasalisation are in opposition. The vowels in (8.76) would have the articulatory representations in (8.77):

(8.77) \{|a|\} \quad \{|a + n|\} \quad \{|n + a|\}

/ɑ/ \quad /ɑ/ \quad /ã/

Finally, notice that I have treated the nasality component as being a component of the articulatory gesture. In this respect, I follow Catford's phonetic treatment of the nasal area as one of the three major areas of the vocal tract, with the consequent characterisation of nasal sounds within the locational sub-component in Catford's model. Ladefoged (1971), however, treats the nasal/oral oppo-
osition within a fourth major component - the oro-nasal process. Phonologically, then, a similar treatment would involve the creation of a fourth gesture, of which \(|n|\) will be the only component. There does not seem to be any crucial phonological reason to choose one solution rather than the other; for simplicity, then, I retain Catford's categorisation.

8.10 Place of articulation: some conclusions

The proposals which have been made in the last few sections are of a somewhat more tentative nature than those concerning the characterisation of vowels. However, I believe that the various suggestions successfully meet the requirements put on a model of phonological representation in chapter 1, and which are not met by the various versions of feature theory, both binary and multivalued, which have been proposed in this area. That is, we have avoided the problems posed by the *SPE* binary interpretation of place, which, as Ladefoged (1971: 102) points out, "makes claims about the natural classes which are necessary in phonological description which seem . . . to be unfounded"; claims which are inherent in the binary system simply because of the large number of putatively 'natural' classes which can be defined by the model. On the other hand, we have largely avoided the weakness apparent in the multivalued system, whereby in order to be able to specify just those classes involving different places of articulation which do recur in phonological processes, a feature such as [gravity] has to be postulated in addition to the feature [place]. Finally, the characteristics of the dependency model have enabled us to show relative complexity of phonological systems in the expected way; the more complex the system, the greater is the number of components and/or relations of dependency holding between the components.
In §5.2 I outlined some arguments which appeared to show that what has been interpreted as a single phonetic component of phonation, i.e. "activities...described chiefly in terms of postures and movements of the vocal cords" (Catford 1977:16), is phonologically relevant to more than one of the gestures which I established in that chapter. Specifically, I attempted to show that Ladefoged's (1971) scalar feature of [glottal stricture] can be given a more natural interpretation with respect to phonological phenomena if the two different phonetic parameters involved - i.e. the degree of glottal stricture and the presence or absence of vocal cord vibration - are separated, such that the presence or absence of vocal cord vibration is characterised by the representations of the categorial gesture, as in chapter 6, while the degree of glottal stricture proper is interpreted as being relevant to a different gesture - the initiatory gesture.

The arguments in favour of this approach are given support by the phenomena surveyed in chapters 6 and 7. As we have seen, what is crucial to the kind of hierarchies which could be established in §§6.3 and 6.4 is the binary opposition between voicing and lack of voicing - i.e. between the presence and absence of vocal cord vibration, represented (at least for obstruents) by the presence vs. absence of a subjoined [V]. The physically independent parameter of glottal stricture - i.e. the degree of opening of the vocal cords, whether in vibration or not - appears to be phonologically relevant only for those languages which have an opposition amongst more than two states of the glottis, such as Indonesian (see §9.1), which distinguishes be-
between voicelessness, 'lax' voice, and 'tense' voice. I suggest that the greater phonological complexity of such systems — involving a three-way, rather than a simple binary opposition — can be reflected in the model being developed here by the introduction of an extra component, specifically one of glottal opening, which was discussed briefly in §7.4.5, and whose nature is further explored in §9.1. For languages in which no more than a simple binary opposition is made in this area, and whose phonological systems are correspondingly less complex, the phonological representations will not require the presence of the component of glottal opening, and their relative simplicity is thus reflected in an obvious manner. We will see that it is the nature of the interaction between glottal opening and the representations of the categorial gesture established in chapter 6 which makes it appropriate to claim that the component of glottal opening belongs to a separate gesture, rather than being a third distinct component (besides \[V\] and \[C\]) within the categorial gesture. Further support for this interpretation will be found in the behaviour of languages which utilise more than just a pulmonic egressive airstream mechanism alone, and which are thereby more complex, in requiring an extra component (at least) in their phonological representations. Languages using only a pulmonic egressive airstream mechanism, I will claim, are like languages making only a binary opposition between voicing and voicelessness in requiring only the representations of the categorial gesture (and of course the articulatory representations of chapter 8) to characterise their phonological systems. Languages having oppositions between airstream mechanisms require the introduction of extra components reflecting this, and are thus shown to be more complex.

9.1 Glottal stricture

I discussed briefly in §5.2.2 Ladefoged's characterisation of phonation by means of a scalar feature [glottal stricture]. I consider here in greater detail the kind of data which Ladefoged (1971: 7-19, 1973, 1975:121-124) uses to establish the need for this feature.
Ladefoged notes that, phonetically, perhaps as many as 9 states of the glottis (i.e. different degrees of glottal stricture) occur in languages:

(9.1) 9 voiceless
8 breathy voiced
7 murmur
6 lax voice
5 voice
4 tense voice
3 creaky voice
2 creak
1 glottal stop

(9.1) represents a continuum "extending from the most closed position, a glottal stop, to the most open position observed in speech, which is that in voiceless sounds" (1971:18). Notice that Ladefoged (1973) gives the feature [glottal stricture] with rather different values, as in (9.2):

(9.2) 1 spread
2 voiceless
3 murmur
4 slack
5 voice
6 stiff
7 creaky
8 closed

(9.1) and (9.2) make essentially the same claims; however, notice that (9.2) incorporates an extra value [spread]. This value is posited in order to account for voiceless aspirated sounds. I return to a discussion of these sounds in §9.4.

However, although there is such a wide range of possible phonation types available, Ladefoged shows that no language makes contrasts involving more than three states of the glottis phonologically. Most languages have only two-way oppositions in this area. Examples of languages with a three-way distinction are given in (9.3) and (9.4):

(9.3) Gujarati (Ladefoged 1971:13)

<table>
<thead>
<tr>
<th></th>
<th>voiceless</th>
<th>murmured</th>
<th>voiced</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[por]</td>
<td>[bar]</td>
<td>[bar]</td>
</tr>
<tr>
<td>/por/</td>
<td>/bar/</td>
<td>/bar/</td>
<td></td>
</tr>
</tbody>
</table>
(9.4) Margi (Ladefoged 1968:65, 1971:15)

<table>
<thead>
<tr>
<th>Voice Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voiceless</td>
</tr>
<tr>
<td>Voiced</td>
</tr>
<tr>
<td>Laryngealized</td>
</tr>
<tr>
<td>(creaky voice)</td>
</tr>
<tr>
<td>/tátá/</td>
</tr>
<tr>
<td>/bábál/</td>
</tr>
<tr>
<td>/bábaí/</td>
</tr>
</tbody>
</table>

While (9.5) (Ladefoged 1971:17) illustrates how the continuum is split up in various languages:

(9.5) 9 voiceless  (all languages)

<table>
<thead>
<tr>
<th>Voice Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voiceless</td>
</tr>
<tr>
<td>Breathy voice</td>
</tr>
<tr>
<td>Murmur</td>
</tr>
<tr>
<td>Lax voice</td>
</tr>
<tr>
<td>Voice</td>
</tr>
<tr>
<td>Tense voice</td>
</tr>
<tr>
<td>Creaky voice</td>
</tr>
<tr>
<td>Creak</td>
</tr>
<tr>
<td>Glottal stop</td>
</tr>
</tbody>
</table>

The data leads Ladefoged to propose the scalar feature [glottal stricture], and he claims:

There is a great deal of explanatory power in the concept of a feature of glottal stricture on which some of the glottal states are rank ordered. A feature of this kind makes a number of linguistic facts easier to explain. (1971:19).

It shows, for example, that murmured or breathy sounds are 'between' voiced and voiceless sounds, and may therefore be grouped with either, phonologically.

For the languages in (9.3) - (9.5), then, the feature [glottal stricture] has, in the classificatory matrix, three values /2 1 0/, which are rewritten phonetically as, for example, [9 7 5] in Gujarati, [9 5 3] in Margi, and [9 6 4] in Indonesian. The feature, then, is not binary, either phonologically or phonetically, contrary to the phonological binary features used to characterise phonation by Jakobson et al (1952), SPE, and perhaps most importantly, by Halle and
Stevens (1971). As was noted with respect to Thráinsson's analysis of preaspiration in Icelandic, Halle and Stevens offer an analysis of phonation-type by using four binary features, which are claimed to be adequate to account not only for glottal stricture, but also for various tonal phenomena, and for voice onset time. I shall here be concerned in particular with the way in which these features operate with respect to phonation-type.

The four features used correspond to only two phonetic parameters: the degree of stiffness of the vocal cords, and the degree of glottal opening. The features are [stiff vocal cords], [slack vocal cords], [spread glottis], and [constricted glottis]. On the parameter of 'stiffness of the vocal cords', sounds may be [+stiff v.c., -slack v.c.], [-stiff v.c., -slack v.c.], or [-stiff v.c., +slack v.c.], but not, because of the way in which the features are defined, [+stiff v.c., +slack v.c.], while the same holds on the glottal opening parameter - sounds cannot be simultaneously [+spread glottis] and [+constricted glottis]. Thus, as in the case of the SPE features [high] and [low], it is clear that in each case a scalar variable is being forced into a binary feature analysis. What Halle and Stevens are in fact doing, as Ladefoged (1973:82) points out, is expressing two ternary oppositions in terms of four binary features.

The vocal cord stiffness parameter essentially characterises the difference between voiceless and voiced sounds - it corresponds to the SPE feature [voice] - voiced sounds being [+slack v.c.], and voiceless sounds [+stiff v.c.]. The interpretation of the glottal opening parameter is obvious. Thus, creaky voiced sounds are [+constr.gl.], voiced sounds [-constr.gl., -spread gl.], and breathy voiced sounds [+spread gl.], according to Ladefoged's (1973:80) representation of various kinds of stops in certain languages. Notice, however, that 'ordinary' voiceless plosives are [-constr.gl., -spread gl.], in order to be able to distinguish these from aspirated plosives which are [+spread gl.]. Some of the feature assignments are shown in (9.6):
However, as both Ladefoged and Catford point out, Halle and Stevens' system suffers from a procrustean tendency to force all items into the nine categories which are available within the system, with the result that certain feature assignments do not appear to correspond to phonetic reality. Catford (1977: 108), for example, shows that the feature specifications for voiced plosive [b] and voiced implosive [b] are suspect:

It seems ... that the only reason for assigning the features [+constricted glottis] and [-slack vocal cords] to [b] is the procrustean one that this particular feature-combination is otherwise unused: there is no empirical justification for thinking that [b] necessarily has either less slack vocal cords or a more constricted glottis than [b].

Similarly, to Ladefoged (1973: 82) "it seems most unlikely that the vocal cords are [+slack, -stiff] in creaky voiced sounds". In addition, we might observe that voiced and voiceless plosives are given the same glottal opening characterisation, while in Ladefoged's scalar feature they have very different values.

Nevertheless, the Halle and Stevens proposals show one important parallel with the system being developed here, in that the parameters of vocal cord vibration and glottal opening are characterised by distinct features, while, as we have seen, Ladefoged's [glottal stricture] feature subsumes both parameters.

Notice again that Ladefoged's feature is rank-ordered, i.e. for each successive point on the continuum, the glottis is more open (or closed) than for the previous one. I propose that such a rank-order-
ing can be naturally reflected by the introduction of a dependency component within the initiatory gesture; specifically the component of glottal opening, which was mentioned in §7.4.5, and which is represented as [0]. If, in the phonological representation of a segment (in those languages which make a three-way opposition in this area), the component [0] occurs, there will be some degree of glottal opening. Similarly, the degree of glottal opening is reflected by the relative prominence of the component in the representation for the segment in question. Thus, the component [0] corresponds more closely to the Halle and Stevens features [spread glottis] and [constricted glottis] than to Ladefoged's [glottal structure], inasmuch as it characterises only degree of glottal opening, and leaves the state of the vocal cords out of account.

However, we clearly need to establish what is meant by 'relative prominence of [0]' - in other words, with what does [0] show dependency relations? [0] cannot enter into the same kind of relations as the components of the categorial gesture. Specifically, while [V] and [C] enter into relations with each other, the difference between three phonation-types (e.g. /p/ vs. /b/ vs. /b/ in Hausa) involves only a single component in the initiatory gesture - for /p/ [0] is more prominent than for /b/, for which in turn [0] is more prominent than for /b/, as in (9.7):

\[
\begin{array}{ccc}
(9.7) & 0 & 0:?
\end{array}
\]

I propose that such segments are appropriately represented if we consider the initiatory and categorial gestures to enter into dependency relations with each other. Thus, while there will be some kind of dependency structure within the categorial gesture, and possibly, indeed, within the initiatory gesture (see §9.5), dependency relations will also hold between the two gestures, as in (9.8):

\[
\begin{array}{ccc}
(9.8) & \text{init} & \text{cat:init} & \text{cat} \\
& \text{cat} & & \text{init}
\end{array}
\]
which, for the segments in (9.7), involves the following representations:

\[
\begin{align*}
(9.9) & \quad 0 \quad \text{C;V:0} \quad \text{C;V} \\
& \quad \text{/p/} \quad \text{/b/} \quad \text{/b/}
\end{align*}
\]

For /p/, with the greatest degree of glottal opening of the three segments in (9.9), \(0\) (as the representation of the initiatory gesture and the component of glottal opening) governs \(\text{C}\) (the representation of the categorial gesture); for /b/, with the smallest degree of glottal opening, \(0\) is dependent; and for /b/, the representations of the categorial and initiatory gestures are mutually dependent.

(9.9) allows a formal maximum of three possibilities, which correlates with the empirical maximum number of oppositions found in languages. The representations, then, reflect this empirical maximum, while Ladefoged's scalar feature of [glottal stricture] cannot be said to do this - there appears to be no reason, within the notation which he employs, for allowing only the three values /0 1 2/, rather than /0 1 \ldots n/, where \(n\) could be any positive integer.

Notice that (as in Ladefoged's system) different phonetic phonation-types may have the same phonological representations, and, indeed, the same phonetic types may have different phonological representations in different systems, as in (9.10):

\[
\begin{align*}
(9.10) & \quad \text{Gujarati} \quad \text{Kumam} \quad \text{Indonesian} \quad \text{Hausa} \quad \text{Margi} \\
& \quad 0 \quad \text{voiceless stops} \quad \text{voiceless stops} \\
& \quad \text{C;V:0} \quad \text{breathy} \quad \text{murmur/} \quad \text{lax voice} \quad \text{voice} \quad \text{voice} \\
& \quad \text{C;V} \quad \text{voice} \quad \text{voice} \quad \text{lax voice} \quad \text{voice} \quad \text{creaky} \quad \text{voice} \\
& \quad 0 \quad \text{voice} \quad \text{creaky} \quad \text{voice} \quad \text{tense voice} \quad \text{creak} \quad \text{creaky} \quad \text{voice}
\end{align*}
\]
(9.10) brings out the fact that the phonological notation employed shows the function of a particular phonation-type within the phonological system of a particular language, rather than showing the particular phonetic realisation of that phonation-type.

9.1.1 Glottal stops

There is a fourth possibility in relation to the representations of the initiatory gesture besides those in (9.8) (in which the initiatory gesture is governing, mutually dependent, or unilaterally dependent); i.e. that it may be absent, even in a phonological system with a three-way opposition in the area under discussion. Absence of \( 0 \), then, would correlate with lack of glottal opening - i.e. a representation lacking \( 0 \) would be that for a glottal stop. The system for Tagalog in (9.5) would be:

\[
\begin{array}{ccc}
\& C; V: 0 & C \\
C & \text{voiceless stop} & \text{voiced stop} & \text{glottal stop}
\end{array}
\]

The treatment of the glottal stop raises some problems. In §5.1 I discussed the view that \( ? \) is frequently a realisation of the neutralisation of a contrast amongst the voiceless stops, i.e. that it bears the same sort of relationship to voiceless stops as the reduced vowel does to full vowels. I argued there, following Lass (1976), that \( ? \) differed from voiceless stops only in the absence of any supraglottal locational information - i.e. in the complete absence of any representation in the articulatory gesture for the glottal stop. Further, there is a phonetic similarity between the two types of segment. Although the state of the glottis is quite different, both the glottal stops and the voiceless stop have the effect of blocking the airstream completely, thus causing a period of silence during the closure phase. In Catford's terms (1977:104), both the voiceless stops and the glottal stop may have an articulatory function.

These facts suggest that we should, if necessary, be able to
characterise voiceless stops and the glottal stop as a natural class, and, in the notation developed here, this is easily achieved; only these segments have |C| alone as the representation of the categorial gesture. Thus, although the two types of segment occur at opposite ends of Ladefoged's scalar feature - and as such cannot readily be characterised as forming a natural class - the system developed here allows just this possibility, in that it distinguishes between glottal opening and vocal cord vibration, and incorporates the notion of gesture.

9.2 Voiceless sonorants

Some languages have phonological oppositions between corresponding pairs of voiced and voiceless sonorants - both consonants and vowels. Examples of minimal pairs in Burmese involving voiced and voiceless nasals and laterals are given by Ladefoged (1971:11):

(9.12) mā 'healthy'  nā 'pain'  ṇā 'fish'
     ṇā 'order'  ṇā 'nostril'  ṇā 'retn'
     la 'moon'
     ḫā 'beautiful'

In the representations of the categorial gesture established in chapter 6, no allowance was made for the representation of voiceless sonorants. Indeed, the representations which were developed for sonorants, showing |V| alone in governing position, seemed appropriate in that they reflected the fact that sonorants are 'naturally' voiced, as opposed to obstruents, which may be naturally voiced or voiceless.

If this is the case - that sonorants are naturally voiced - then it seems reasonable to assume that a system such as (9.12), involving phonological oppositions between voiced and voiceless sonorants, should be characterised as more complex than a system involving only oppositions between voiced and voiceless obstruents. Our phonological notation should, in turn, reflect this relative complexity. I suggest that it is appropriate, in representing voiceless sonorants, to intro-
duce the dependency component |0| - the component of glottal opening. For such segments, then, the categorial gesture (containing the usual representation for the sonorant in question) will be dependent on the initiatory gesture (containing |0|):

\[(9.13) \begin{array}{c|c|c}
0 & 0 & 0 \\
V;V,C & V;C & V \\
voiceless liquids & voiceless nasals & voiceless vowels
\end{array}\]

In such a system, the voiced counterparts of the segments in (9.13) will show a structure in which |0| is dependent on the representations of the categorial gesture; in this way, the complexity of a system involving an opposition between voiced and voiceless sonorants is successfully represented.

We are now in a position to formulate a condition on any segment with |0| in governing position, viz: a segment with |0| (as a component of the initiatory gesture) governing the categorial gesture is voiceless. This condition holds only if all languages with a three-way opposition in phonation-type have, as one of these types, voiceless segments - a state of affairs which does, in fact, appear to be universally true. Thus, for voiceless sonorants, the specification for glottal opening (|0|) overrides the inherent specification for vocal cord vibration in the categorial gesture (governing |V| alone). Segments with governing |0|, but without a voicing specification in the categorial gesture (e.g. the voiceless stops in (9.10)), of course, lack vocal cord vibration in any case. The naturalness of this condition is apparent in that segments with governing |0| show a large degree of glottal opening. Such a glottal configuration is incompatible with the presence of vocal cord vibration, which can only occur with a relatively small degree of glottal opening. The claim that voiceless sonorants retain a sub-structure which characterises voiced sonorants can be defended by the fact that such segments retain traces of the formant patterns associated with their voiced counterparts.
This treatment of voiceless sonorants, then, allows us to show the relative complexity of phonological systems employing this segment-type, by the need to introduce representations of the initiatory gesture in their characterisation. Compare this with a feature system, where it is not possible (except by using ad hoc accretions such as the markedness theory of SPE) to reflect the relative complexity of such systems, as shown in (9.14) and (9.15):

(9.14) \[
\begin{align*}
+\text{son} & & +\text{son} & & -\text{son} & & -\text{son} \\
-\text{voice} & & +\text{voice} & & -\text{voice} & & +\text{voice} \\
\text{voiceless} & & \text{voiced} & & \text{voiceless} & & \text{voiced} \\
\text{sonorants} & & \text{sonorants} & & \text{obstruents} & & \text{obstruents}
\end{align*}
\]

(9.15) \[
\begin{align*}
2\text{ glottal stricture} & & 1\text{ glottal stricture} \\
1\text{ sonorant} & & 1\text{ sonorant} \\
\text{voiceless} & & \text{voiced} \\
\text{sonorants} & & \text{sonorants}
\end{align*}
\]

\begin{align*}
2\text{ glottal stricture} & & 1\text{ glottal stricture} \\
0\text{ sonorant} & & 0\text{ sonorant} \\
\text{voiceless} & & \text{voiced} \\
\text{obstruents} & & \text{obstruents}
\end{align*}

9.3 Phonetic representations involving \(0\)

In the preceding, I have indicated how a component of glottal opening can account for the phonological oppositions holding amongst different phonation-types. However, the conditions established there on representations involving \(0\) appear not to be applicable to phonetic representations in this area. Although only a three-way contrast is required to characterise different phonation-types phonologically, there are many more phonetic possibilities. The constraints on the phonological representations allow only three possibilities, and so we must extend our notation to account for the phonetic possibilities.

I suggest that this can be achieved by relaxing the constraints on the kind of dependency relations that can hold between \(V\), \(C\), and \(0\) at the phonetic level. Rather than dependency relations being confined to holding between the two gestures as a whole, it is appropriate, I claim, to drop this constraint at the phonetic level, to
allow the individual components to enter into dependency relations with each other, in the manner indicated in (9.16):

(9.16) glottal stop  creaky voice  voice  murm  murmur  voiceless

<table>
<thead>
<tr>
<th></th>
<th>V</th>
<th>V</th>
<th>V</th>
<th>O</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>[I]</td>
<td>[I]</td>
<td>[I]</td>
<td>[I]</td>
<td>[I]</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>V,C</td>
<td>V,C:O</td>
<td>O</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[I]</td>
<td>[I]</td>
<td>[I]</td>
<td>[I]</td>
<td>[I]</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>C:O</td>
<td>O</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[n]</td>
<td>[n]</td>
<td>[n]</td>
<td>[n]</td>
<td>[n]</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>V,C</td>
<td>V,C</td>
<td>V,C</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>V:O</td>
<td>O</td>
<td>V</td>
<td>V;C</td>
<td></td>
</tr>
<tr>
<td>[z]</td>
<td>[z]</td>
<td>[z]</td>
<td>[z]</td>
<td>[z]</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>V:O</td>
<td>O</td>
<td>C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[?]</td>
<td>[d]</td>
<td>[d]</td>
<td>[d]</td>
<td>[t]</td>
<td></td>
</tr>
</tbody>
</table>
I have selected in (9.16) what appear to be the most important states of the glottis (cf. Ladefoged 1975:258). As the degree of glottal opening is phonetically a continuum, any selection of points is arbitrary. Further, I suggest that in phonetic representations vowels are represented by a structure \(|V| + |V|\), to allow the expression of the full range of phonatory possibilities.

The representations in (9.16) are internally consistent, in that, for example, all creaky voiced segments show \(|O|\) in dependent position. Within each major class of segments (vowels, fricatives, etc.) the relationship between the various possible degrees of glottal opening remains the same. In addition, the position of \(|O|\) in the tree never disturbs the dependency relations holding between the representations of the categorial gesture. For all nasals, for example, whatever the state of the glottis, we find the sub-structure \(|V| + |C|\). Finally, notice that the assignment of the representations to the particular phonetic segment-types is to some extent arbitrary. But, as Ladefoged points out in relation to his system:

The particular numbers (and names) used for the different degrees of glottal stricture are the product of an arbitrary assignment within the theory of general phonetics. But once this assignment has been made, the phonological rules for individual languages can generate phones which can be compared not only with each other but also with phones of other languages. (1971:18).

Exactly the same comment applies to the system in (9.16).

9.3.1 Devoiced obstruents

The extension to the system outlined above allows us to characterise some common phonation-types which occur more frequently as realisations of certain phonetic processes, rather than as segment-types participating in phonological oppositions; i.e. in traditional terms, realisations of particular phonemic types occurring allophonically in certain environments. I have in mind, for example, processes such as final devoicing in English - a process which gives, as the surface realisation of an underlying voiced obstruent, a segment which is voiceless, but which is, in phonetic terms, 'lenis' (or, in Chomsky and Halle terminology, 'lax'). In an \textit{sfe}-type distinctive feature
phonology, the three different types of obstruents would, presumably, be represented as (9.17):

(9.17) \[
\begin{array}{ccc}
\text{[+voice]} & \text{[-voice]} & \text{[-voice]} \\
\text{voiced} & \text{voiceless} & \text{devoiced}
\end{array}
\]

or, in the Halle and Stevens notational system, as (9.18):

(9.18) \[
\begin{array}{ccc}
\text{[-stiff]} & \text{[+stiff]} & \text{[-stiff]} \\
\text{[+slack]} & \text{[-slack]} & \text{[-slack]}
\end{array}
\]

Thus, although obstruents underlyingly have opposite values for [voice] and [tense] (or for [stiff] and [slack]), a segment such as the final one in English <keys> [ki:] might have the feature-values [-voice, -tense] ([-stiff, -slack]).

Devoiced obstruents can be given a natural characterisation using the type of representation in (9.16). If the only difference between, say, the voiced fricative [z] and the devoiced fricative [ɹ] is the degree of glottal opening, then (9.19) seems appropriate as the phonetic representation for [ɹ]:

(9.19) \[
0
\]

\[
\begin{array}{cc}
V, C \\
V
\end{array}
\]

\[
\text{devoiced}
\]

\[
\text{fricatives}
\]

in which \( |0| \) is promoted to governing position, in accordance with the greater degree of glottal opening and with the constraint by which segments with governing \( |0| \) have no vocal cord vibration. Similarly, devoiced stops would have the representation in (9.20):
(9.19) and (9.20) bring out the 'intermediate' status of the devoiced obstruents with respect to the normal voiced and voiceless obstruents. However, Catford (1977:112) notes that glottographic and laryngoscopic studies show that these devoiced stops display "considerable whisper-like narrowing of the glottis". If this is so, (9.19) and (9.20) are inappropriate, in that they show representations in which the vocal cords are maximally open. Rather, the phonetic state of affairs is more adequately captured by (9.21):

\[(9.21) \quad V, \ C: O \quad \text{devoiced} \\
\quad C: O \quad \text{fricatives} \quad \text{stops}\]

in which \( |0| \) is relatively less prominent than in (9.19) and (9.20), but still more prominent than in the representations for the voiced obstruents in (9.16). Such an interpretation requires that we extend the phonological constraint whereby segments with governing \(|0|\) show no vocal cord vibration, so that in phonetic representations (with a far greater range of dependency relations), a segment with governing \(|0|\), either alone or mutually dependent with other components, shows no vocal cord vibration. And, indeed, if the devoiced obstruents do in fact show a whisper-like configuration of the vocal cords, the representations in (9.21) will be given support by the characterisation of the whispered segments in the following section.

9.3.2 Whispered segments

In the production of whispered segments, the "vocal cords are
together or narrowed except between the arytenoids" (Ladefoged 1971:8; cf. Catford 1977:96-97). For this phonation-type, the vocal cords are not in vibration. Whisper is not generally used systematically in linguistic communication, but it is clearly desirable to be able to characterise it in phonetic representations; we saw, for example, in the previous section that stops may be realised phonetically with the vocal cords in a whisper-like configuration. For obstruents, the following representations seem suitable:

(9.22) \( V, C: 0 \)  \( C: 0 \)

\[ \begin{array}{ll}
\text{whispered} & \text{whispered} \\
\text{fricatives} & \text{stops}
\end{array} \]

The representations differ from those for voiceless obstruents in that \( |0| \) is mutually dependent with the governing element, rather than governing alone, because of the narrowing of the glottis. The lack of vocal cord vibration for these segments is characterised, as in (9.21), by the fact that \( |0| \) is not unilaterally dependent on anything (and also, of course, by the absence of dependent \( |V| \)). Whispered lenis obstruents will have the representations assigned to the devoiced obstruents in the previous section, i.e. those in (9.21). Similarly, (9.23) gives the phonetic representations for whispered sonorants:

(9.23) \( V: 0 \)  \( V: 0 \)  \( V: 0 \)

\[ \begin{array}{lll}
\text{whispered} & \text{whispered} & \text{whispered} \\
\text{vowels} & \text{liquids} & \text{nasals}
\end{array} \]

The treatment of glottal opening and vocal cord vibration as independent parameters allows us to offer a characterisation of whispered segments, whereas Ladefoged's feature [glottal stricture], associated only with vibration of the vocal cords (except when the glottis is maximally open or closed), "leaves no way of accounting for whispered sounds" (Ladefoged 1971:19).
9.4 Aspiration

I return now to a further consideration of the representation of aspiration in dependency phonology. As noted in §7.4.5, it has been argued by, for example, Kim (1970), Petursson (1976), and Catford (1977) that degree of aspiration correlates directly with degree of glottal opening. Thus, Kim (1970:108) observes that Korean has three types of voiceless stops, which differ from each other in degree of aspiration, as in (9.24):

(9.24)  Labial  Dental  Velar

I /p'ali/ 'washer' /t'ai/ 'daughter' /k'al/ 'villain'
II /pal/ 'leg' /tal/ 'moon' /kali/ 'stack'
III /phal/ 'arm' /thal/ 'mistake' /khali/ 'knife'

where series I is the "unaspirated" series, series II the "slightly aspirated" series, and series III the "heavily aspirated" series.

Kim shows, by means of a "cineradiographic film of the laryngeal area" that the degree of glottal opening correlates with the degree of aspiration. The film shows:

a narrow glottis in I, a moderately open glottis in II, and a wide open glottis in III. The striking feature to be noted...is that there seems to be a direct correlation between the degree of the glottal opening at the time of the release and the degree of aspiration.

It seems, then, that in the dependency model, these stops differ from each other only in the relative prominence of [0], as in (9.25):

(9.25)  C  C:0  0

0 0 0
/p'/ /p/ /ph/

in which [0] becomes more prominent as the degree of glottal opening, and hence of aspiration, increases.

It might be objected that in the "unaspirated" series we would expect the [0] to be absent, rather than dependent as in (9.25).
However, such a representation would characterise a glottal stop (cf. §9.1.1); for the 'unaspirated' series, as Kim notes, there is some glottal opening, albeit less than for series II and III.

A second objection to the representations in (9.25) might be that aspirated stops are treated as units, rather than as a sequence of oral closure followed by a period of aspiration. However, the phonetic evidence cited in §7.4.5 appears to support this analysis. Further, the auditory correlate of aspiration, i.e. the voicing-lag between the release of the oral closure and the onset of voicing, "is only a symptom of what may be regarded as a more fundamental characteristic of these sounds, namely, the state of the glottis" (Catford 1977:114). On phonemic grounds, too, it has been argued in various cases that aspirated stops should be unit phonemes. In the Applecross dialect of Scots Gaelic, for example, which shows oppositions between stops based on aspiration rather than voicing, Ternes (1973:21-22) argues that the aspirated stops should be treated as single phonemes, on grounds of "phonetic realisation" and "pattern congruity" with respect to the operation of initial consonant mutation.

Notice that these arguments tend to support this treatment of aspiration (i.e. as being determined by degree of glottal opening) rather than that of Ladefoged (1975:258), whose definition of the feature [aspiration] refers to "time of onset of voicing with respect to release of the articulation". (Indeed, Ladefoged 1973:78 calls this feature [voice onset], rather than [aspiration].) Notice that Ladefoged claims that:

since what are commonly called aspirated sounds can be made with two different degrees of glottal stricture (voiceless and murmur), it seems inadvisable to try to collapse the notion of aspiration within that of glottal stricture. (1973:77).

Ladefoged's feature may have the values [aspirated], [unaspirated], and [voiced]:

Sounds that are voiced throughout the articulation will be said to have a value of 0 percent, those in which the voicing starts at the time of the release of the articulation will have a value of 50 percent, and those in which the voicing starts considerably later will be 100 percent Aspirated. (1975:261).
Further support for the interpretation of \(0\) as aspiration and as voicelessness in the case of the 'voiceless sonorants' can be found in Ternes' account of Scots Gaelic. He is concerned (1973:72ff) with the "phonemic interpretation of the voiceless/aspirated sonorants". Notice first of all that he devotes a great deal of discussion to whether these should be interpreted biphonemically or monophonemically (cf. the discussion in §7.4 of various phenomena), and suggests that there are four possible interpretations, as in (9.26):

(9.26) (1) biphonemic /\(hn, hl, hL, hr/\)
(2) biphonemic /\(nh, nh, Lh, rh/\)
(3) monophonemic /\(g, l, L, s/\)
(4) monophonemic /\(nh, l^h, L^h, rh/\)

(where /\(L/\) is a phonemically velarised lateral).

I return below to the biphonemic/monophonemic question, but in the meantime let us consider the choice between (3), in which "voicelessness" is the phonemically distinctive feature, and (4), in which "aspiration" is distinctive. Whatever the arguments which Ternes adduces for choosing between the two (in fact his choice is (4)), the issue is simply irrelevant within the dependency system. A voiceless sonorant, in this view, is phonologically identical to an 'aspirated' sonorant, given the monophonemic view, and the fact that it is voiceless. Thus, on either interpretation, the representations will be:

(9.27) 0 0

\[V;C \quad V;V,C\]

\[g/n^h \quad l/l^h; L/L^h; s/r^h\]

However, it should be noted that the representations in (9.27) are phonological, not phonetic. Phonetically, there is a distinction between what one might call voiceless sonorants (voiceless throughout) and aspirated sonorants (which may show voicelessness only during a part of their production). Indeed Ternes notes:

The so-called voiceless n-, l-, and r- sounds are hardly ever voiceless throughout. In general, the postaspirated varieties start voiced and become voiceless, the preaspirated varieties start voiceless and become voiced. (1973:70).
I return below to a possible characterisation of this.

(Post-)aspiration, as we have seen, can be interpreted as a component of the stop itself, as in (9.25), while preaspiration, as argued in §7.4.5, differs in that the \( |0| \) component is sequentially distinct from the \( |C| \) component, as in (9.28):

\[
(9.28) \quad 0 \quad c \\
\quad [ h \quad p ]
\]

In discussing Icelandic preaspiration, I suggested that aspiration might be interpreted as a prosody whose domain is a consonant cluster forming a syllabic onset or coda. Such an approach gains support from the fact that preaspiration and postaspiration are mutually exclusive - i.e. a consonant (cluster) has only a single 'specification' for aspiration; a specification which may be realised only in one 'place' in the string of segments forming a cluster. However, the representations offered in §7.4.5 do not in themselves appear to reflect the prosodic status of governing \( |0| \) in such structures - there seems to be no reason why structures with two governing \( |0| \) specifications should be prohibited. I want to show now that there are various other phenomena which suggest that aspiration is prosodic, and I shall offer a more formal representation of the notion of a prosody whose domain is the syllabic onset or coda.

Evidence for the prosodic status of \( |0| \) can be drawn from the behaviour of consonant clusters, notably clusters of sonorant+voiceless stop, or voiceless stop+sonorant. As we saw in §7.4.5, clusters of (underlying) voiced sonorant and (underlying) aspirated stop in Icelandic are realised either as voiceless sonorant+(voiceless) unaspirated stop, or as voiced sonorant+(voiceless) aspirated stop, according to dialect. However, there are no dialects in which the surface realisation is either voiceless sonorant+aspirated stop, or voiced sonorant+unaspirated stop (cf. (7.110) - (7.113)). I associated this with the notion that governing \( |0| \) is prosodic, and is asso-
ciated with the whole $|C|$ cluster. The two permissible clusters, then, show a single occurrence of governing $|V|$; the non-occurring clusters either zero or two occurrences.

Similarly, Catford (1977:116) notes that "in English, initial $[p, t, k]$ plus $[l, r, w]$ or $[j]$ involves a fully or partially voiceless second term in the initial cluster, that is $[pl, tw, kj]$ and so on", and claims that this can be attributed to the fact that:

Initial voiceless consonants, or voiceless consonant-clusters, always begin with the glottis widely open. The time-lag between this wide open state of the glottis, and fully vibrating vocal cords for the following vowel is always roughly the same; alternatively, approximately the same quantity of air is always driven through the glottis in any English voiceless syllable onset.

Thus the specification of the initial stop as having governing $|O|$ (because English initial voiceless stops are aspirated) means that the whole consonant cluster is specified as having governing $|O|$ (because only one governing $|O|$ specification per cluster is allowed).

However, because the stop is followed by a sonorant consonant, the $|O|$ is realised phonetically not as aspiration on the stop, but as devoicing of the sonorant, a state of affairs which might be represented as:

\[(9.29)\]

\[
\begin{array}{c}
\text{O} \\
\text{C} \\
\text{V} \\
\text{V,C} \\
\text{[p \downarrow]} \\
\end{array}
\]

The fact that $|C|$ remains dependent on $|O|$, although sequentially distinct is, I suggest, sufficient to specify the appropriate degree of glottal opening; otherwise it would be interpreted as a glottal stop.

Similar explanations are advanced by Kim (1970:114) and by Catford for the fact that the stop is unaspirated in $[sC]$ clusters of the sort discussed in §7.4.6. As the glottis is wide open for the $[s]$, the change from the open position to the voicing position is completed at more or less the same time as the release of the closure
for the stop; hence the stop is unaspirated. Again, then, only one of the segments in the cluster displays governing [0], as in (9.30):

\[(9.30) \quad \begin{array}{c}
0 \\
V: C \\
\end{array} \quad \begin{array}{c}
C \\
\end{array}
\]

\[\begin{array}{c}
[\text{`}s \\
\end{array} \quad \begin{array}{c}
p \end{array} \]

Whether or not such constraints are universal, i.e. whether or not we can associate universally with each consonant cluster only a single governing [0] specification, it is clear that such a constraint is apparent in the range of data surveyed above. At least for these phenomena, then, I would claim that [0] is a prosody, whose domain is the consonant cluster.

However, the representations in (9.29) and (9.30) do not, it seems to me, in any way reflect the prosodic nature of [0]. Rather, these representations may be appropriate as phonetic, rather than phonological representations, in that they specify in what way the governing [0] component is realised; i.e. as postaspiration on a stop, as preaspiration, as devoicing of a sonorant, or whatever. The phonological representations (or, in some cases, representations at least more abstract than the surface phonetic), I suggest, have a rather different character, which I shall attempt to illustrate below.

I return firstly to the case of preaspiration in Icelandic, which will provide us with an example in which, it can be argued, the underlying segments differ from the surface phonetic. It will be recalled that Icelandic displays 'preaspirated stops' which Thráinsson analyses as a period of aspiration followed by a stop. However, he suggests (1978: §§2, 3) that "all cases of preaspiration in Icelandic are derived by a rule"—specifically, that a sequence such as [ht] is derived from a sequence of two voiceless aspirated stops, i.e. from /tt/. Thus [feiht] <feitt> 'fat' is derived from underlying /feitt/. As Thráinsson characterises [h] as being unspecified for supralaryngeal features (cf. chapter 3), and as the laryngeal features for stops and [h] are the same in the Halle and Stevens system which he uses,
such a rule involves merely deletion of the supralaryngeal features of the first of the two stops.

We have already established that the surface representation of [ht] in dependency phonology consists of |0| followed by dependent |C|. How, then, does the phonological representation differ? It seems clear that, in the lexicon, the rhymes of syllables such as the above would show a sequence of segments like that in (9.31):

(9.31) V 0;C 0;C

i.e. a vowel followed by two aspirated stops. If the syllabification rules were to apply in the expected way, however, we would get a structure such as (9.32):

(9.32) *V

\[ \begin{array}{c}
\text{O} \\
\text{C} \\
\text{C}
\end{array} \]

which, at least for Icelandic, is ill-formed in having two governing |0| specifications. Rather, I suggest, the prosodic nature of |0| can appropriately be reflected by a representation such as (9.33):

(9.33) V

\[ \begin{array}{c}
\text{O} \\
\text{C} \\
\text{C}
\end{array} \]

In (9.33), |0|, as a prosody whose domain is the complete coda of the syllable, is dependent on |V|, the syllabic governor. In turn, the two |C|s show an internal dependency relation, such that the first |C| governs the second, but the resulting structure (i.e. the syllable
coda) is, as a whole, subjoined to the prosody |0|. Thus the notion 'domain of a prosody' is brought out in the representation; the complete structure forming its domain is subjoined to the prosodic element.

However, a structure like (9.33) would be disallowed as a surface phonetic structure; it is not possible to determine from (9.33) how |0| is realised phonetically. In the case of Icelandic, then, the preaspiration rule operates; the first |C| is deleted, thus allowing the second |C| to be directly dependent on |0|, giving (9.34):

(9.34) V
     \--
      O
     \--
      C

Notice that this approach appears to resolve the difficulties which Pétursson (1972b:106) notes with respect to Liberman's (1971) prosodic analysis of preaspiration, viz. that "la préaspiration de l'islandais moderne apparait comme une unité segmentale". While this is phonetically appropriate, and is represented in structures like (9.34), there is no need to assume that this is the case phonologically.

The derivation of stop + sonorant and [sC] clusters in, for example, English will proceed similarly. Thus, in the surface phonetic representations we find (9.35) and (9.36) for initial [p|] and [sp]:

(9.35) V
     \--
      O
     \-- C
  \-- V;C, V
  [p \---- V]

(9.36) V
     \--
      O
     \-- C
  \-- V;C
  \-- C
  \-- V;
  [s p \---- V]

The lexical representations of such sequences, however, will not contain |0|, as aspiration is not a relevant phonological para-
meter in English. Lexical entries, then, will contain simply:

(9.37) \( C \ V; V, C \ V \)  (9.38) \( V: C \ C \ V \).

which will become respectively (9.39) and (9.40) by the syllabification rules:

(9.39) \( V; V, C \)
(9.40) \( V: C \)

At a level intermediate between the phonological and surface phonetic, \( |0| \) must be assigned to the initial cluster, as a prosody whose domain is the whole cluster, to give (9.41) and (9.42):

(9.41) \( V \)
(9.42) \( V: C \)

Language-specific phonetic realisation rules will then assign the \( |0| \) to the appropriate segment (the governor in both cases), to give (9.35) and (9.36) above.

Similarly, in the Icelandic data in (7.110) - (7.113), involving a sonorant followed by a stop, we can propose an intermediate representation (9.43):

(9.43) \( V \)

\( V; V, C \)
In this case, the phonetic assignment of \( |0| \) is dialect-specific; either it is assigned to the sonorant, to give \([\lambda p]\), or to the stop, to give \([\lambda ph]\).

Exactly the same kind of phenomena can be seen in two other Icelandic processes cited by Thráinsson (1978:40-41). A "dental spirant" followed by a stop shows the same behaviour as the sonorants considered above:

(9.44) maðkur 'worm' \([\text{mæðkyr}] \quad [\text{maðk̊yr}] \quad *[\text{maðk̊yr}] \quad *[\text{maðk̊yr}]\]

with deaspiration in the dialects showing devoicing, and no deaspiration in those retaining voicing of the spirant. In all dialects, too, /r/ is devoiced before /pt k/, which are consequently deaspirated:

(9.45) sår \([səʊɛːr]\) \quad sárt \([səʊɛːt]\)

Thráinsson shows further that any sequence of fricative + underlyingly aspirated stop in Icelandic is realised as a voiceless fricative + deaspirated stop (cf. the [sC] clusters considered above), as in (9.46):

(9.46) leysti 'untie' (past) \quad [lɛɪstɪ]
    hreyft 'move' (past part.) \quad [Χɛɪft]
    gleypti 'swallow' (past) \quad [klɛɪftɪ]
    rakt 'moist' (neuter) \quad [rækt]

The range of data surveyed above, then, seems to support the point of view that in such cases governing \(|0|\) - the component of glottal opening - should be treated as a prosodic element whose domain is a complete consonant cluster.

I return now to the problem of the biphonemic or monophonemic interpretation of the "voiceless sonorants" of Scots Gaelic (see (9.26)). One of the disadvantages which Ternes notes in relation to either biphonemic solution is that they entail a complicated description of the allophones of such clusters - sometimes the biphonemic cluster /hn/ is realised as a "single sound", e.g. [q̊h] (i.e. as a sound which starts voiced and becomes voiceless), sometimes as a...
sequence in which aspiration precedes the sonorant, and sometimes as one in which aspiration follows the sonorant.

If we adopt the prosodic interpretation of \(|O|\) outlined above, this problem disappears. Phonologically, the voiceless/aspirated sonorant (i.e. /hn/, /nh/, /ŋ/, or /n^h/) is viewed as a structure in which governing \(|O|\) is a prosody whose domain is, in this case, the single segment \(|V > C|\); phonetically, the position of the realisation of \(|O|\) may vary, as in (9.47):

\[(9.47) \quad 0 \quad 0 \quad 0 \]

\[V;C \quad V;C \quad V;C \]

\[[hn] \quad [ŋ] \quad [nh] \]

I suggest, then, that the question as to which of the four phonemic solutions should be adopted with respect to these forms does not arise in this framework; phonologically, there is only one possibility.

Finally in this section I want to consider two cases where \(|O|\) is the only element in the syllable onset or coda. The first is the case of preaspiration of vowels in Welsh, already mentioned in §7.4.5, which I characterised as involving a structure \(|O| \pm |V|\), \(|O| < |V|\). The second is a case discussed by Ternes (1973:80-89), the case of "final h" in the Applecross dialect.

Under certain circumstances "some kind of h" is heard postvocally. For example, after "short stressed vowel before pause" h is heard:

but it is hardly ever strong and distinct. It has no specific tongue and lip position of its own. Tongue and lips simply maintain the positions assumed for the preceding vowel, a kind of devoiced prolongation of that vowel.

Thus, Ternes argues, such sequences may be transcribed in either of the ways in (9.48):
(9.48) [priʰ] [pri˨] 'boiled, cooked'
[māʰ] [mā˧] 'good'
[ʃi˨ʰ] [ʃi˨˧] 'this'

(9.49) seems an appropriate representation for these 'post-aspirated vowels' in dependency phonology:

(9.49) V
      0

In (9.49) (as in the representation for preaspirated vowels in Welsh) 0 is dependent on V, because V, as the characteristic element of the syllable, is therefore its governor. The fact that the 0 'segment' has the same articulation as the vowel in such cases is, it seems to me, appropriately reflected by representations such as (9.49). Notice that there is no specification in the articulatory gesture for 0. Thus, its articulatory properties are determined by those of the element on which it is dependent, i.e. the vowel.

9.5 Airstream mechanisms

I turn now to another aspect whose characterisation seem appropriate to the initiatory gesture - the use of different airstream mechanisms in speech production. In the preceding I have tacitly assumed that all sounds are produced on one airstream - the pulmonic. Although in many languages this is of course the case (at least systematically), there are two other airstream mechanisms used in the production of speech in many languages; the glottalic and the velaric (Abercrombie 1967:28-33, Catford 1967:63ff, Ladefoged 1971:23-31). The following table is taken from Ladefoged (1971:23):
The principal airstream mechanisms

<table>
<thead>
<tr>
<th>Airstream</th>
<th>Direction</th>
<th>Brief description</th>
<th>Type of</th>
<th>Symbols</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulmonic</td>
<td>Egressive</td>
<td>Lung air pushed out under the control of the respiratory muscles</td>
<td>Plosive</td>
<td>p t k</td>
</tr>
<tr>
<td>Glottalic</td>
<td>Egressive</td>
<td>Pharynx air compressed by the upward movement of the closed glottis</td>
<td>Ejective</td>
<td>p' t' k'</td>
</tr>
<tr>
<td>Glottalic</td>
<td>Ingressive</td>
<td>Downward movement of the vibrating glottis</td>
<td>Implosive</td>
<td>b d g</td>
</tr>
<tr>
<td>Velaric</td>
<td>Ingressive</td>
<td>Mouth air rarefied by the backward and downward movement of the tongue</td>
<td>Click</td>
<td>ɹ ɹ ɹ</td>
</tr>
</tbody>
</table>

Two parameters can be distinguished: firstly, whether the airstream mechanism is ingressive or egressive, i.e. in Catford's terms, whether suction or pressure is involved (1977:64); and secondly, the location of the initiation of the sound, i.e. which organs carry out the "initiatory activity". (9.51) (from Catford) shows the possibilities:

<table>
<thead>
<tr>
<th>location</th>
<th>direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>lungs</td>
<td>pulmonic pressure</td>
</tr>
<tr>
<td>larynx</td>
<td>glottalic pressure</td>
</tr>
<tr>
<td>mouth</td>
<td>velaric pressure</td>
</tr>
</tbody>
</table>

In (9.51) the mechanisms actually occurring in systematic linguistic communication are italicised. According to Catford, pulmonic suction and velaric pressure, although anthropophonically possible, are not linguistically used.

Notice that Ladefoged points out that glottalic ingressive sounds are produced with a downward movement of the vibrating glottis; i.e. there is also a pulmonic egressive airstream mechanism involved in the production of these implosives. (Catford 1977:76, however, offers a rather different interpretation of these sounds. He shows that the airflow is only quasi-egressive, in that what is involved is
the downward movement of the glottis over a static air column - the relative movement of the glottis and the air column thus generating 'voice'.

Ladefoged (1971:25) also points out that glottalic ingressive sounds with no vocal cord vibration - i.e. implosives with a closed glottis - are found in language, but are rare. However, according to Greenberg (1970:126), most Munda languages have a "full set of four injective [i.e. implosive] unvoiced stops in final position", and so, in what follows, I will include these sounds in an attempt to offer a characterisation of different airstream mechanisms.

9.5.1 Pulmonic airstream mechanisms

By definition, a sound involving a pulmonic airstream mechanism must involve an open glottis. Thus, any sound involving a pulmonic airstream mechanism can be characterised phonetically, and, if necessary, phonologically, by the presence of the component [O]. Therefore, although [O] is defined as characterising glottal opening, its presence may also be taken to characterise a pulmonic egressive airstream mechanism. The fact that the pulmonic airstream mechanism is phonologically the least complex accords well with the interpretation offered here; it does not prove necessary, within the model, to provide a component whose sole function is to characterise the use of this airstream mechanism.

9.5.2 Glottalic airstream mechanisms

As shown in (9.51), the glottalic airstream mechanism may be egressive or ingressive. If it is egressive, the glottis is closed, and the whole larynx is raised and constricted, "so that the pressure of the air in the mouth and the pharynx [i.e. between the closed larynx and the articulatory stricture] tends to be raised" (Ladefoged 1971:25). Sounds produced on a glottalic egressive airstream mechanism are known as ejectives, or glottalic pressure sounds, and are usually stops, although some ejectives are recorded. Ladefoged (1971:25) offers the following contrasts in Amharic:
As noted above, sounds produced on a glottalic ingressive air-stream usually (but not always) involve some vibration of the vocal cords. Whether or not the larynx is tightly closed, it is lowered, thus reducing the pressure between it and the articulatory stricture, and causing air to enter the mouth when the articulatory closure is released. Only stops can be implosive. A series of voiced implosive stops is found in Sindhi (Ladefoged 1971: 26), which also has a series of voiced stops, voiceless aspirated and unaspirated stops, and breathy voiced stops. The contrasts involving the labial set are:

(9.53) bənî bənu pənu pʰənu benenu
       'curse' 'forest' 'leaf' 'snake hood' 'lamentation'

Ladefoged sets up a feature [glottalicness], which uses "the fact that implosives and ejectives differ in terms of the single parameter of rate of vertical laryngeal movement toward the lungs" (1971: 30). At the systematic phonetic level, his system would presumably offer some characterisation such as the following:

(9.54) [-n glottalic] ejectives
       [ 0 glottalic] plosives
       [+n glottalic] implosives

where the value of n would indicate "the degree of force with which the glottalic airstream mechanism was used". He claims as an advantage of this feature the fact that it can describe "weakly implosive allophones which occur in many languages in certain environments; and it also formalises the fact that a sound cannot be simultaneously an ejective and an implosive" (1971:30).

Notice that Chomsky and Halle (SPE:322-324) use two binary features to characterise this mechanism: [implosion] (or [glottal suction]) and [ejection] ([glottal pressure]). Ejectives are [-implo-
sion, +ejection], implosives [+implosion, -ejection], and other sounds [-implosion, -ejection]. Again, the formally possible combination of [+implosion, +ejection] is excluded by the definition of the features, both of which involve movement of the glottal closure - downward for [implosion] and upward for [ejection].

I propose that in the dependency model glottalic airstream mechanisms should be characterised by a component in the initiatory gesture |G| - a component of glottalicness. |G|, as a component of the initiatory gesture, will show dependency relations with the categorial gesture in the same manner as |O| - in other words, dependency relations will hold between the two gestures. A representation in which the initiatory gesture, containing |G|, governs the categorial gesture will characterise a glottalic egressive sound; a representation in which the reverse holds, i.e. in which the initiatory gesture is dependent on the categorial, will characterise a glottalic ingressive sound. Ordinary pulmonic sounds, represented as [O glottalic] by Ladefoged, will, I suggest, lack the component |G|. (9.55) represents the three possibilities:

(9.55) a. init b. cat c. cat
    cat glottalic egressive pulmonic glottalic ingressive

It will be noted that (9.55) differs from the somewhat similar display (9.8) (showing the possible relations between the categorial gesture and the initiatory gesture containing |O|, rather than |G|), in that the middle term in (9.55) does not show mutual dependency between the two gestures, as in (9.8). This, I claim, is due to the fact that the pulmonic airstream mechanism characterised by the middle term in (9.55) does not, in fact, represent an intermediate point between glottalic egressive and glottalic ingressive. It is, of course, possible to interpret (9.55b) as intermediate between (9.55a) and (9.55c) if we view the only parameter in question as being the relative height of the glottis, as in (9.56):
(9.56)  
1. glottis raised - glottalic egressive  
2. glottis in normal position - pulmonic (or glottal stop)  
3. glottis lowered - glottalic ingressive  

(9.56) would suggest a continuum, on which the various points could be characterised in the manner of (9.8). However, the component \(|G|\) should not be taken as characterising the position of the glottis alone, but rather the presence of glottalic initiation, together with relative height of the glottis. Only sounds with glottalic initiation, then, will show \(|G|\), whose relative prominence will then be determined by the height of the glottis. Thus, glottalic egressives, involving glottalic initiation plus raising of the glottis, show governing \(|G|\); glottalic ingressesives (glottalic initiation plus lowering of the glottis) show dependent \(|G|\); and pulmonic egressives (or glottal stops), involving no glottalic initiation, lack \(|G|\) (cf. Ladefoged's \([0\) glottalic]). Such a characterisation has, I think, two benefits: firstly, segments with the glottis in the 'normal' position are less complex than those with glottalic initiation; secondly, the treatment of \(|G|\) as having two phonetic correlates allows us to account naturally for certain allophonic realisations of plosives and implosives (see below).

Applying this system to various sounds produced with a closed glottis, i.e. those not employing a pulmonic airstream mechanism, and therefore lacking \([0\), we have the display in (9.57):

\[
\begin{array}{c|c|c}
\text{G} & \text{C} & \text{C} \\
\text{C} & /p'/ & /\theta/ & /\delta/ \\
\end{array}
\]

I turn now to various sounds involving vocal cord vibration. Consider first, for the purposes of illustration, a (hypothetical) system in which there is a three-way opposition in phonation-type, e.g. /b/ vs. /b/ vs. /b/, together with an opposition between a pulmonic egressive airstream mechanism and a glottalic ingressive airstream mechanism, such that each of /b/, /b/, /b/ has a corresponding
voiced implosive, i.e. /b/ vs. /b/ vs. /b/. Such a system would represent the theoretically maximal number of oppositions in this area, but would not be expected to occur, as the maximum number of oppositions in phonation-type is three, of which one must be voiceless. The representations for the pulmonic egressive sounds, established in §9.1, would be:

\[(9.58) \begin{array}{c} C;V \\ C;V:O \\ O \\ /b/ \end{array} \]

These representations lack \(|G|\), as the segments do not show glottalic initiation.

The series of voiced implosives will, however, show \(|G|\) as well as \(|O|\). I propose that for these segments it is the nature of the components within the initiatory gesture itself which determines the characterisation of the segments involved. Specifically, the only segments which contain both \(|O|\) and \(|G|\) are the voiced implosives - as ordinary plosives contain no \(|G|\), and there are no voiced glottalic pressure segments (Catford 1977:77-78). Thus the presence of \(|O|\) and \(|G|\) in simple combination is sufficient to characterise voiced implosives, as in (9.59):

\[(9.59) \begin{array}{c} C;V \\ C;V:O:G \\ O.G \\ /b/ \end{array} \]

In (9.59), the relationships between \(|O|\) and the categorial gesture remain constant with respect to (9.58). What I am proposing, then, is that it is only in the absence of \(|O|\) that the relationship between \(|G|\) and the categorial gesture is crucial, as in (9.59). If \(|O|\) is present, only one kind of glottalic airstream mechanism is possible - i.e. that for the voiced implosive - and so the presence of \(|G|\) is sufficient to characterise this. Similarly, there is no need
to propose a dependency relation between \(|G|\) and \(|O|\) in (9.59) — there is no opposition to be made with any other combination of \(|G|\) and \(|O|\). We see also that the phonologically more complex series of voiced implosives have a more complex representation than the series of pulmonic stops.

I offer here what seem to be appropriate representations for some typical phonological systems involving the use of both glottalic and pulmonic airstream mechanisms:

(9.60) Sindhi (Ladefoged 1971:26)
\[
\begin{array}{c|c|c|}
C; V & C; V: O & 0 \\
\hline
0. G & C; V & C \\
/b/ & /b/ & /p/ \\
\end{array}
\]

(9.61) Hausa (Ladefoged 1968:64)
\[
\begin{array}{c|c|c|}
C; V: O & 0 & G \\
\hline
0 & C & C \\
/g/ & /k/ & /k/ \\
\end{array}
\]

(9.62) Uduk (Ladefoged 1971:27)
\[
\begin{array}{c|c|c|}
C; V & C; V: O & 0 \\
\hline
0. G & C & C \\
/B/ & /b/ & /p/ \\
\end{array}
\]

Phonological representations like these can be related to phonetic representations in a way similar to that discussed for segments involving \(|O|\). For segments involving \(|O|, |G|, |V|,\) and \(|C|\), i.e. various voiced implosives with different degrees of glottal stricture, the following seem appropriate phonetic representations:

(9.63)
\[
\begin{array}{c|c|c|}
C & C & C \\
\hline
V & V: O. G & O. G \\
\hline
0. G & V & [\alpha] \\
\end{array}
\]
in which |O| and |G| are in simple combination, because the simple presence of both is sufficient to characterise a voiced implosive, as noted in the previous section.

The representations for glottalic sounds involving no vocal cord vibration will be similar to their phonological representations:

\[(9.64) \quad C \quad G \quad \quad G \quad C \quad [t] \quad [t']\]

(9.63) retains the advantages discussed above with respect to phonetic representations involving only |O| in the initiatory gesture, in that it allows us to represent in an obvious way various important phonetic processes. I discuss two of these below: firstly, the possible allophonic realisation of voiced plosives as weakly implosive; and, secondly, the free variation of voiced implosives and laryngealised stops, both of which phenomena noted by Ladefoged.

One of the advantages that Ladefoged claims for his scalar feature [glottalic] is that "it provides a nice way of describing weakly implosive allophones which occur in many languages in certain environments" (1971:30). The occurrence of such allophones, Ladefoged claims, is because the difference between implosives and plosives is one of degree, rather than kind (1971:17) (but see again Catford 1977:76). The advantages which Ladefoged claims are also apparent in the model being developed here. Consider the phonetic representations for the pulmonic voiced stop and the voiced implosive:

\[(9.65) \quad C \quad C \quad \quad V:0 \quad V:0:G \quad \text{voiced plosives} \quad \text{voiced implosives}\]

(Notice that in (9.65) we find |O| ≠ |G|, for reasons that will become apparent below.)
Voiced plosives differ from voiced implosives only in lacking \(|G|\) — i.e. they do not employ the glottalic airstream mechanism. The weakly implosive allophones of voiced plosives which Ladefoged discusses differ from voiced stops in having glottalic initiation, but differ from 'normal' voiced implosives in that the implosion is weak. (9.66) seems an appropriate characterisation of such segment-types:

\[
(9.66) \quad C
\]

\[
V:O
\]

\[
G
\]

(9.66) differs from the representation for voiced plosives in having \(|G|\), and from that for implosives in the relative prominence of \(|G|\) (hence the mutual dependency relation in (9.62)), thus reflecting the 'weak' uses of the glottalic airstream mechanism.

With respect to the second of the phenomena, Ladefoged (1968:16) notes the following:

Laryngealized voicing often occurs during a voiced implosive.... We can separate out two kinds of laryngealized consonants: what we are here calling voiced implosives ..., in which there is always a downward movement of the glottis — and there may or may not be laryngealized voicing; and what we are here calling laryngealized consonants ..., in which there is always a particular mode of vibration of the vocal cords — and there may or may not be a lowering of the larynx.

He notes the need for a feature characterising glottalic airstream mechanisms in such a way that it can interact with the features which are concerned with the state of the glottis. In terms of the dependency model, then, \(|O|\) and \(|G|\) should be able to interact — which, as we have seen, is essential in any case to the proper characterisation of the phenomena surveyed in this chapter. This can be illustrated with respect to the particular problem discussed by Ladefoged. (9.67) represents the two types:
If we consider first laryngealised plosives with some implosion, (9.68) seems an appropriate representation:

(9.68)  
```
(9.67)  C C
V
0
```
laryngealised voiced plosives implosives

If, now, we display the four segment-types as (9.70), we see that (9.68) and (9.69) are each shown to be intermediate between the two representations in (9.67):
9.5.3 Velaric airstream mechanisms

In the use of the velaric airstream mechanism:

a body of air is enclosed by raising the back of the
tongue to make contact with the soft palate, and either
closing the lips or (more commonly) forming a closure
on the teeth or alveolar ridge with the tip (or blade)
and sides of the tongue. The air in this chamber is
rarefied by the downward and backward movement of the
body of the tongue, the back of the tongue maintaining
contact with the soft palate. When a more forward part
of the closure is released, air rushes into the mouth,
and a sound known as a click is produced. This mecha-
nism is always ingressive, and there are no reports of
its use in the formation of sounds other than stops.
(Ladefoged 1971:28).

The airstream mechanism can be used simultaneously with a pulmonic
airstream mechanism, and Ladefoged (1971:30) offers the following
oppositions in series of dental clicks in Zulu:

(9.71) voiceless voiced voiced murmured
un aspiration click nasal click nasal click

*

'climb'

'dance at
wedding'

'gather
unripe corn'

'act quickly'
For /g\艷/, there is vocal cord vibration, simultaneously with the velar closure; for /n\艷/, there is breathy voice, and lowering of the velum, both of which cooccur with the velaric airstream mechanism. Clearly, all sounds involving a velaric and a pulmonic airstream mechanism simultaneously have closure at the velum.

Ladefoged characterises the velaric airstream mechanism by means of a feature [velaric suction]. This feature is binary at the phonological level, as no oppositions are made between different degrees of this mechanism. In the dependency model, this state of affairs is simply captured by a component which I shall label |K| - a component which will be present if the mechanism is employed, and absent otherwise. Sounds involving a velaric airstream mechanism are shown to be phonologically more complex than those which do not. I propose (9.72) as suitable representations for the segment-types in (9.71):

(9.72) C.K C:V V:C V:C:O.K

\[ /g\艷/ \]
\[ /n\艷/ \]
\[ /n\艷/ \]

in which, for those sounds involving (necessary) glottal opening, no dependency relation between [O] and [K] is posited, as there is no way in which this can be phonologically relevant.

Little need be said about the representation of the velaric airstream mechanism at the phonetic level. Although phonologically there is no distinction to be made amongst degrees of click, Ladefoged (1971:31) notes that there are different kinds at the phonetic level - "powerful" in Ngumi languages, and with "a wide range of weak uses" in West African languages. This difference can be captured by the prominence of the |K| component. Thus, in Yoruba and Idoma, the use of the click mechanism is 'weak', while in Zulu it is 'strong'. The difference might be characterised as:
9.5.4 <kp> sounds

Ladefoged (1968) discusses a number of different sounds corresponding to the orthographic form <kp> in a number of West African languages. These sounds differ in a number of ways concerned with airstream mechanisms, and Ladefoged distinguishes three types.

The first type occurs, for example, in Late (1968:9), and consists of "simply the simultaneous articulation of k and p... superimposed on a pulmonic airstream". Such a sound, then, involving only a pulmonic airstream mechanism in a language which does not appear to utilise any other airstream mechanism (1968:52), would have the representation for a voiceless plosive in the categorial gesture: no representation in the initiatory gesture is required, as no opposition is made in Late in this area. The difference between /kp/ and, for example, /p/ in Late would be captured in the representations of the articulatory gesture only (cf. (8.71)).

The second type, which occurs in Yoruba, involves two airstream mechanism - the velaric ingressive and the pulmonic egressive. After the double closure is made, the back of the tongue is retracted, thus reducing the pressure in front of the velar closure, while behind the velar closure the pressure is high, because of the pulmonic egressive airstream. When the closure is released, the air flows in both directions into the mouth. Such sounds, then, representing the 'weak' use of the click mechanism mentioned above, require both [O] and [K] in their representations, as in (9.74):

(9.74) C:O.K

The third type, in, for example, Idoma, differs from type two in that, simultaneously with the retraction of the tongue, the vibrating
glottis is lowered, as in the production of a voiced implosive. Thus, all three airstream mechanisms are employed in the production of these sounds. Such highly complex sounds might have the representation:

\[(9.75) \; C; V: 0. G. K\]

where, again, no dependency relations between \( |K|, |O|, \) and \( |G| \) are required.

It should be noted that the representations in (9.74) and (9.75) are perhaps more fully specified than necessary, if they are taken to be fully non-redundant phonological representations of the languages in question. However, I am not concerned here with such redundancies, which are internal to phonological systems, although in §9.6 I note some redundancies which may be universally true of phonological systems. Rather, (9.74) and (9.75) (and other representations in this chapter) might be taken as very broad phonetic specifications, rather like the normal form of the systematic phonetic representations in an SPE-type phonology.

9.6 Some generalisations holding between the gestures

In (9.76) - (9.79) I offer some constraints which appear to hold universally between the categorial and initiatory gestures.

\[(9.76) \{G \leftrightarrow \emptyset\} \Rightarrow \{C \leftrightarrow \emptyset\}\]

(a sound involving a glottalic airstream mechanism must be a stop)

\[(9.77) \{\sim O\} \Rightarrow \{\sim V\}\]

(voicing presupposes a pulmonic airstream mechanism — glottal opening)

\[(9.78) \{0, G\} \Rightarrow \{C \neq V\}\]

(all voiced implosives are stops)

\[(9.79) \{K, O\} \Rightarrow \{C \neq V\} \lor \{V \neq C\}\]

(clicks produced with a simultaneous pulmonic egressive airstream mechanism involve either a pulmonic voiced stop or a nasal)
Chapter 10

The Phonological Representation
of the Welsh Mutations

The first large scale process which I shall examine in some de-
tail is the phenomenon of initial mutation in Modern Welsh, and in
this chapter I shall offer an interpretation in terms of the phonolo-
gical framework which has been developed in the preceding chapters.
This interpretation will largely be based on the analysis proposed by
Griffen (1975, 1976); that is, it is not my intention to offer here a
full account of the various phenomena, but rather to indicate in what
ways dependency phonology can characterise the relations between the
segments in the various mutation processes. I shall, however, also
consider a distinctive feature approach to these phenomena, that of
Awbery (1973), who gives a generative account of the mutation system
in Welsh, with respect to both syntax and phonology.

As Griffen (1975:1) points out, "the mutation systems of the
Celtic languages function in much the same way as the inflectional
systems of languages such as Latin" (see also Hamp 1951). Similar
systems occur in the other Celtic languages; see, for example, Ternes
(1973:69ff) on Scots Gaelic, Ó Dochartaigh (ms:a) on Irish, Jackson
(1955:130-133) on (literary) Manx, Smith (1972:14) on Cornish, and
Jackson (1967:308ff) on Breton. In such mutation systems, particular
grammatical contexts trigger the operation of one of the three muta-
tion processes affecting a word-initial segment, and the "radical"
segment is altered to give the appropriate mutated segment. For ex-
ample, in Welsh, the first person singular possessive adjective <fy>
triggers the nasal mutation process, while the masculine and feminine
third person singular possessive adjectives, which are identical in
form (<ei>), trigger respectively the soft mutation and spirant muta-
tion processes. This is illustrated in the forms in (10.1), taken from Bowen and Rhys Jones (1960:166), which show the way in which the various mutation processes operate:

<table>
<thead>
<tr>
<th>(10.1)</th>
<th>radical</th>
<th>soft mutation</th>
<th>nasal mutation</th>
<th>spirant mutation</th>
</tr>
</thead>
<tbody>
<tr>
<td>pen 'head'</td>
<td>ei ben 'his head'</td>
<td>fy mhen 'my head'</td>
<td>ei phen 'her head'</td>
<td></td>
</tr>
<tr>
<td>tad 'father'</td>
<td>ei dad 'his father'</td>
<td>fy nhad 'my father'</td>
<td>ei thad 'her father'</td>
<td></td>
</tr>
<tr>
<td>ceffyl 'horse'</td>
<td>ei geffyl 'his horse'</td>
<td>fy ngheffyl 'my horse'</td>
<td>ei cheffyl 'her horse'</td>
<td></td>
</tr>
<tr>
<td>basged 'basket'</td>
<td>ei fasged 'his basket'</td>
<td>fy masged 'my basket'</td>
<td></td>
<td></td>
</tr>
<tr>
<td>desg 'desk'</td>
<td>ei ddesg 'his desk'</td>
<td>fy nesg 'my desk'</td>
<td>no change</td>
<td></td>
</tr>
<tr>
<td>gardd 'garden'</td>
<td>ei ardd 'his garden'</td>
<td>fy ngardd 'my garden'</td>
<td></td>
<td></td>
</tr>
<tr>
<td>mam 'mother'</td>
<td>ei fam 'his mother'</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>llong 'ship'</td>
<td>ei long 'his ship'</td>
<td>no change</td>
<td>no change</td>
<td></td>
</tr>
<tr>
<td>rhosyn 'rose'</td>
<td>ei rosyn 'his rose'</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The radical segment, then, is the one realised if none of the mutation rules apply. The relationship between the radicals and the various mutated segments is presented as (10.2) (adapted from Griffen 1975:4):

<table>
<thead>
<tr>
<th>(10.2)</th>
<th>radical</th>
<th>soft mutation</th>
<th>nasal mutation</th>
<th>spirant mutation</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;p&gt; /p/</td>
<td>&lt;b&gt; /b/</td>
<td>&lt;mh&gt; /m/ (<em>/m</em>/)</td>
<td>&lt;ph&gt; /f/</td>
<td></td>
</tr>
<tr>
<td>&lt;t&gt; /t/</td>
<td>&lt;d&gt; /d/</td>
<td>&lt;nh&gt; /n/ (<em>/n</em>/)</td>
<td>&lt;th&gt; /θ/</td>
<td></td>
</tr>
<tr>
<td>&lt;c&gt; /k/</td>
<td>&lt;g&gt; /g/</td>
<td>&lt;ngh&gt; /ŋ/ (<em>/ŋ</em>/)</td>
<td>&lt;ch&gt; /χ/</td>
<td></td>
</tr>
<tr>
<td>&lt;b&gt; /b/</td>
<td>&lt;f&gt; /v/</td>
<td>&lt;m&gt; /m/</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;d&gt; /d/</td>
<td>&lt;dd&gt; /ð/</td>
<td>&lt;n&gt; /n/</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;g&gt; /g/</td>
<td>(deletes)</td>
<td>&lt;ng&gt; /ŋ/</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;m&gt; /m/</td>
<td>&lt;f&gt; /v/</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;l&gt; /l/</td>
<td>&lt;l&gt; /l/</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;rh&gt; /r/ (<em>/r</em>/)</td>
<td>&lt;r&gt; /r/</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Notice that the forms given in (10.2) are those found in standard Welsh. Various differences can be found in dialectal forms. Thus in the Nantgarw (Glamorgan) dialect (Thomas 1961) there is no \(/\xi\)/, and so forms with orthographic <rh> do not participate in the mutation processes in Nantgarw. Similarly, in Nantgarw, nasal mutation of \(/p\ t\ k\)/ gives the same as nasal mutation of \(/b\ d\ g\)/; i.e. ordinary voiced nasals, for example \(/\text{men}/\) instead of \(/\text{m\text{en}}/\).

The problem with which Griffen is concerned is how to characterise the relationships between the radicals and the various mutated forms. He notes that under certain grammatical conditions, any of the segments in the radical column will undergo soft mutation - a "single process" - to give the segment in the soft mutation column. However, an account in terms of a distinctive feature framework is inadequate for the characterisation of this process in any unitary fashion.

The difficulties which Griffen notes are apparent in Awbery's treatment. Awbery uses a fairly traditional set of SPE-type features, and treats the radicals as underlying forms (systematic phonemes), which are converted into the appropriate mutated forms by phonological rules. She characterises the soft mutation processes as involving two phonological rules, as follows:

\[
(10.3) [-\text{voice}] \rightarrow [+\text{voice}] / [-\text{cont}] \\
(10.4) [-\text{cont}] \rightarrow [+\text{cont}] / [+\text{voice}] -\text{nas} -\text{ljq}
\]

Rule (10.3), as expected, covers the changes \(\{p\}, \{t\}, \{k\} \rightarrow /b/, /d/, /g/\), and rule (10.4) \(\{b\}, \{d\}, \{g\} \rightarrow /v/, /\delta/, /\gamma/\) (where the use of vertical brackets denotes the underlying form or radical - cf. Griffen 1975; I return in a moment to the change \(\{g\} \rightarrow /\gamma/\)). However, (10.3) is, within the feature system which Awbery uses, also adequate to characterise the changes \(\{l\}, \{\xi\} \rightarrow /l/, /r/\). These segments, then, have the feature assignment \ [+\text{cons}, +\text{voc}, -\text{cont}]\). It is difficult to
see that this decision can be justified: Awbery herself notes that "the possibility of making this generalisation is the only evidence at present available that the liquids are [-cont]". In other words, a feature which is potentially phonetic is being used as nothing more than a diacritic marker to ensure that the necessary forms undergo the rule.

It will be seen that the application of (10.4) to radical \(|g|\) gives /\(ь/\), while the segment is not in fact realised at surface level. Awbery suggests that "the change \(g \rightarrow \text{ь}\) be carried out parallel to the two other cases \([|b| \rightarrow /v/, \; |d| \rightarrow /\delta/]\), and that this unacceptable \(ь\) segment be deleted by a later rule". A similar strategy is proposed by Zwicky (1974). Notice that both Awbery and Griffen point out that, historically, \(|g|\) gave /\(ь/\) as the soft mutation, with /\(ь/\) later being lost, thus giving the asymmetry in the modern system. Such a process might be taken to support the notion that velars are inherently weaker than labials and dentals; cf. the discussion in chapter 8. It is interesting to notice that soft mutation in Scots Gaelic presents the following pattern (from Ternes 1973:69):

\[
(10.5) \begin{array}{c}
\text{stem initial} \ C \ldots \ p^h \ t^h \ \ell^h \ \ell^h \ k^h \ p \ t \ \ell \ k \\
\text{resulting} \ C \ldots \ f \ h \ h \ \varsigma \ x \ v \ y \ j \ j \ y \\
\text{stem initial} \ C \ldots \ m \ n \ N \ i \ R \ f \ s \ j \\
\text{resulting} \ C \ldots \ v \ n \ n \ l \ r \ \text{zero} \ h \ h
\end{array}
\]

(\(\varsigma\) = palatalisation). In the first row of (10.5) we find a voiceless aspirated series (corresponding to the radicals in the first section of (10.1)) and a voiceless unaspirated series (corresponding to the radicals in the second section of (10.1)); the Scots Gaelic stop system is based on the opposition of aspiration. It will be seen that the soft mutation of the unaspirated velar stop yields the 'expected' /\(ь/\), rather than deleting, as in Welsh. Similarly, Ó Dochartaigh (ms:a) offers (10.6) as the 'lenition paradigm' in Irish:

\[
(10.6) \begin{array}{c}
C_1 : /p \ t \ k \ b \ d \ g \ m \ L \ N \ R \ s \ f/ \\
C_2 : [f \ h \ x \ \tilde{w} \ y \ y \ w \ l \ n \ r \ h \ \emptyset]
\end{array}
\]
One change remains to be characterised in Awbery's treatment of soft mutation, $|m| \rightarrow /v/$. Awbery claims "that the exceptional nature of this change must be reflected in an additional rule, specified as to place of articulation", i.e.:

\[(10.7) \quad [-\text{cont}] \rightarrow [+\text{cont}] / \begin{bmatrix} +\text{voice} \\ \hline +\text{nas} \\ -\text{comp} \\ [+\text{grave}] \end{bmatrix} \]

Yet another rule, a 'specifying' (or phonetic realisation) rule will change the value for the nasality feature.

It will readily be seen that the unitary nature of soft mutation is not captured by Awbery's treatment; notice that Griffen (1975: 9-12), too, presents a set of rules in which, it appears, soft mutation "involves voicing in some cases, continuance in others, deletion in another, continuance and denasalization with desonorization in another, and voicing and vocalization with sonorization in yet others" (1976: 14), as in (10.8):

\[(10.8) \quad \begin{align*}
\text{a. } & |p| \rightarrow /b/ \\
& |t| \rightarrow /d/ \\
& |k| \rightarrow /g/ \\
\text{b. } & |b| \rightarrow /v/ \\
& |d| \rightarrow /\delta/ \\
\text{c. } & |g| \rightarrow \emptyset \\
\text{d. } & |m| \rightarrow /v/ \\
\text{e. } & |s| \rightarrow /l/ \\
& |\xi| \rightarrow /r/ \\
\end{align*} \]

\[(10.8) \quad \begin{align*}
& \begin{bmatrix} +\text{vcd} \\ +\text{asp} \\ -\text{asp} \\ +\text{obs} \\ -\text{cnt} \end{bmatrix} \\
& \begin{bmatrix} +\text{vcd} \\ +\text{asp} \\ -\text{cnt} \\ +\text{obs} \\ -\text{cnt} \end{bmatrix} \\
& \begin{bmatrix} +\text{obs} \\ \text{vcd} \\ +\text{bck} \\
+\text{bck} \\
+\text{vcd} \\
+\text{vcd} \\
+\text{lat} \\
+\text{vcd} \\
+\text{cnt} \end{bmatrix} \]

(It will be seen that Griffen characterises $|g| \rightarrow \emptyset$ directly,}
and $|\xi|$ as being [+cont]; hence the need for five rules, rather than Awbery's three.)

Griffen (1975:7) notes that the set of rules in (10.8) fails to capture the "degree of phonetic unity within this process". This 'phonetic unity' is manifested in terms of each rule in the soft mutation process creating "a segment which is more lenis... than the underlying segment".

Griffen offers an alternative analysis of Welsh mutation (in particular soft mutation). This analysis is carried out within a different phonological framework - the hierarchical model of phonology, discussed in broad outline in §3.4 above. It will be recalled that Griffen characterises the consonant sub-system of Welsh as being organised on the basis of a gradual opposition of 'aspiration', which he views as a prosody superimposed upon the obstruction. Thus, what are traditionally called voiced fricatives have the weakest degree of the prosody ($\eta$), followed by voiced stops ($\varrho$), and voiceless stops ($h$), with voiceless fricatives having the strongest degree of the prosody ($hh$). In addition, there is a nasality prosody ($n$). Thus, the Welsh consonant sub-system in (10.9) is given the hierarchical representation in (10.10):

\[
(10.9) \quad \begin{array}{cccccc}
1 & 2 & 3 & 4 & 2 & 3 \\
v & b & p & f & m & \varrho \\
\delta & d & t & \theta & n & \eta \\
\gamma & g & k & \chi & \eta & \eta \\
\iota & r & \chi & & & \\
\end{array}
\]

\[
(10.10) \quad \begin{array}{ccccccc}
-1 & 0 & +1 & +2 & 0 & +1 \\
b & b & bh & bhh & bn & bhn \\
d & d & dh & dhh & dn & dhn \\
g & g & gh & dhh & gn & ghn \\
\iota & \iota & \chi & & & \\
\varepsilon & \varepsilon & \varepsilon & & &
\end{array}
\]

Using this system, Griffen is able to offer a unitary account
of soft mutation, and his treatment of the process is in this respect more adequate than either of the distinctive feature accounts considered above. Specifically, soft mutation is interpreted as involving a weakening of one degree of the aspiration prosody, from 0 to -1 in the case of voiced stops becoming voiced fricatives, or from +1 to 0 in the case of voiceless stops becoming voiced stops.

In what follows, I shall accept the basis of Griffen's analysis - i.e. that the 'phonetic unity' associated with soft mutation involves aspiration. However, I shall attempt to show that a more natural interpretation of the phenomenon can be given within the framework of dependency phonology, whose characteristics have been established on independent grounds.

I want first to consider the soft mutation process in terms of the representations of the categorial gesture developed in chapter 6. (10.11) represents the relationships between the various sets of segments:

(10.11) a. voiceless stop → voiced stop C → C; V
     b. voiced stop → voiced fricative C; V → V, C; V
     c. |m| → /v/
     d. |t| → /l/ |ç| → /r/ (→ /r/)

Notice that (10.11b) is not adequate to account for the |g| → g change. In that I am not concerned here with the exact nature of the relation between underlying and surface forms, I ignore the problem of whether this change should be represented directly, i.e. by simply marking |g| as phonologically exceptional, or whether the rule should apply regularly, yielding an intermediate stage /γ/, which is subsequently deleted, as argued by Awbery. Ó Dochartaigh (personal communication) proposes a derivation |g| → /γ/ → /r/ → g, which he characterises in dependency terms as:
(10.12) \[ \text{artic} \Rightarrow \text{artic} \Rightarrow g \Rightarrow g \]

\[
\begin{array}{c|c|c|c}
C & V, C & V, C & g \\
V & V & V & g \\
g & y & h & g \\
\end{array}
\]

in which /h/ shows the same relationship to the voiced fricatives as /h/ to the voiceless ones; i.e. it has the same categorial representation as the voiced fricative, but lacks specifications in the articulatory gesture. As support for this derivation, O Dochartaigh notes that in some dialects of Breton [h] appears as the mutated form of /g/.

Although soft mutation appears to be phonologically a unitary process, it is clear that (10.11) only partially represents this. (a), (b), and (d) all involve the segment becoming more \(|V|-like\), by addition of a \(|V|-component\), or, in the case of (d), by subsequent deletion of a \(|C|-component\). (Notice that in many dialects, /r/ has developed into a liquid /r/, a segment which has the same representation in the categorial gesture as /l/.) Thus, in these cases, soft mutation may be characterised as the changing of the radical segment into a more \(|V|-like\) segment (cf. the characterisation of lenition processes in chapter 6). However, (c) does not show this; rather, /v/ is less \(|V|-like\) (in that it shows \(|C|-in governing position\) than the radical \(|m|-\). However, notice that "when Brythonic */m/-occurred between vowels, it was realised in Old Welsh as /\ddot{\text{m}}/-, a voiced bilabial nasal fricative, in Modern Welsh /\text{v}/" (Griffen 1975:2). Observe, too, that in O Dochartaigh's presentation in (10.6) above, the lenition of Irish /m/-is given as [\text{\textbackslash n}]. Thus, at least historically, we see that the mutation of /m/-involves the change of a segment with oral closure (a nasal stop) into one with oral friction (a nasal(ised) fricative).

A more serious objection to (10.11) is that it fails to distinguish soft mutation from spirant mutation (or, as Awbery calls it, the aspirate mutation), i.e. the change of \(|p|, |t|, |k|-to /f/, /\theta/, /x/-, which is characterised by Awbery as:
Spirant mutation may be characterised in the dependency model as:

\[(10.14) \text{voiceless stop} \rightarrow \text{voiceless fricative} \quad C \rightarrow V:C\]

In this case, too, the process appears to involve the addition of a \(|V|\) component. That it is necessary to be able to distinguish the two processes is apparent from the fact that they show a (partly) shared input: the set of voiceless stops can undergo both processes, in different (but predictable) grammatical environments.

These problems may be overcome by appealing to Griffen's notion of the role of aspiration in soft mutation. As we have seen, Griffen's aspiration prosody correlates articulatorily with the width of the orifice of the larynx before consonant release. In chapter 9, I argued that various phenomena involving degree of glottal opening (or stricture) are best characterised by the dependency component of glottal opening, represented as \(|0|\). This component can plausibly be used to characterise Griffen's aspiration prosody in Welsh. Thus, degree of aspiration (i.e. in this interpretation, the amount of "breath... forced out of the cavity" created by the width of the orifice of the larynx, and the resulting pressure - Griffen 1975:284) correlates with the relative prominence of \(|0|\). Recall, too, the treatment of the aspiration phenomena in §9.4, and cf. Ternes' account of the Scots Gaelic consonant system as involving an opposition of aspiration.

With respect to soft mutation, there are three phonologically relevant categories in (10.10): \((u), (\emptyset), \text{and } (h)\) (i.e. the values -1, 0, and +1). These categories can be reinterpreted in the dependency system as follows: segments with the weakest degree of the aspiration prosody have \(|0|\) in dependent position, segments with the basic degree have \(|0|\) mutually dependent with the representation of the categorial gesture, and segments with the strongest degree of the prosody have \(|0|\) in governing position, as in (10.15):

\[(10.13) \text{[-cont]} \rightarrow \text{[+cont]} / \text{[-voice] \text{[-liq]}}\]
The presentation of the segment-types in (10.15) allows a more natural interpretation of soft mutation, as (10.16):

\[(10.16)\]

a. voiceless stop \( \rightarrow \) voiced stop \( 0 \rightarrow C; V: O \) \\

b. voiced stop \( \rightarrow \) voiced fricative \( C; V: O \rightarrow V, C; V \) \\
c. \( m \rightarrow /v/ \) \( V; C: O \rightarrow V, C; V \) \\
d. \( l \rightarrow /l/ \) \( V, C; C: O \rightarrow V; V, C \) \\
\( l \rightarrow /r/ \) \( V; V, C: O \rightarrow V; C: O \)

Soft mutation can be characterised as the reduction in the degree of prominence of \( |O| \) (i.e. governing becomes mutually dependent, and mutually dependent becomes unilaterally dependent), together with an increase in the prominence of the \( |V| \) component. Notice that the change \( m \rightarrow /v/ \), which, as noted above, is deviant in that it does not involve an increase in \( |V| \)-ness (because of the historical sequence */m/ \( \rightarrow */p/ \rightarrow */v/) nevertheless corresponds to the general rule that soft mutation involves reduction in the \( |O| \)-ness of a segment.
To this extent, then, soft mutation of \( |m| \) is synchronically predictable.

Griffen (1975:182) notes that "the gradual opposition of phonologically pertinent aspiration can always predict the phonetic occurrence (or optionality) of voice, but voice cannot predict aspiration". In chapter 9, I argued that such a constraint is also apparent in representations containing \( |O| \). Those phonological representations with \( |O| \) in unilaterally governing position are invariably voiceless, whatever the specification within the categorial gesture, while those with \( |O| \) in mutually dependent or unilaterally dependent position are always voiced, provided that the representation of the categorial gesture specifies a voiced segment. Thus, the 'inherent' specification of segments involving governing \( |V| \) as voiced, such as the nasals, is overridden by the presence of an \( |O| \) governing the \( |V| \). This constraint is also apparent in the representations of (10.15), and the predictability of voice from aspiration is brought out formally in the system, as an independent generalisation which perhaps holds universally.

I suggest that Griffen's claim (1975:182) that "the nature of aspiration as a phonological gradual opposition means that in reality the opposition is ever present in various degrees of realization" is more appropriately reflected in the notational system of dependency phonology than in the ad hoc notions of 'zero-degree' and 'minus-degree' which Griffen himself admits are used "as a mnemonic labelling device". The scalar nature of the aspiration prosody is more appropriately represented in a system in which its representation is always present, and occurs in various kinds of relationship with the segment-types of the categorial gesture.

Spirant mutation, as we have seen, also involves the addition of a \( |V| \) component. However, unlike soft mutation, no reduction in the prominence of the \( |O| \) component is involved. Rather, the phonetic difference in degree of aspiration between voiceless stops and voiceless fricatives (whereby the fricatives have greater glottal opening than the stops) does not appear to be phonologically relevant in
Welsh. Spirant mutation, then, can be characterised as involving the addition of a \( |V| \) component, while both voiceless stops and voiceless fricatives show governing \( |0| \), in that both show a relatively large degree of glottal opening, as in (10.17):

\[
(10.17) \text{voiceless stop} \rightarrow \text{voiceless fricative} \quad 0 \rightarrow 0
\]

Thus, no change in the prominence of the \( |0| \) component is involved in spirant mutation, and it is therefore distinguished from soft mutation.

As noted in §7.4.5, there is a fourth mutation process in Welsh, which Griffen calls the aspirate mutation, and which Awbery treats as a sub-part of the spirant mutation (which she labels as aspirate mutation). This mutation is realised as "preaspiration of an initial vowel" (Griffen 1975:16), and occurs only with certain possessive forms, as in (10.18):

\[
(10.18) \text{ei eglwys} \quad [\text{i eglowis}] \quad \text{'his church'}
\]

\[
\text{ei hglwys} \quad [\text{i heglois}] \quad \text{'her church'}
\]

where the feminine possessive adjective triggers the aspirate mutation process.

Griffen characterises the aspirate mutation process within the distinctive feature framework as (10.19):

\[
(10.19) \quad \emptyset \rightarrow \left[ \begin{array}{c} -\text{voc} \\ -\text{cns} \\ -\text{high} \end{array} \right] / \# \rightarrow \left[ \begin{array}{c} +\text{voc} \\ -\text{cns} \end{array} \right]
\]

However, Awbery's rule for this process involves phonological devoicing:

\[
(10.20) \quad [+\text{voice}] \rightarrow [-\text{voice}] / [-\text{cons}]
\]

with "a later specifying rule ... segment[ing] out the voicelessness".
feature as an h segment". This approach is not dissimilar to that discussed in chapter 7, with respect to [0] and consonant clusters, in which the phonetic realisation of an [0] prosody whose domain is the cluster can vary between, for example, preaspiration, postaspiration, and devoicing. However, the appropriate dependency representation in the case of aspirate mutation is (7.118), repeated here:

(10.21)  

\[ V \]

in which [0] is dependent on [V], as the governor of the syllable. In other words, [0] by itself forms the syllabic onset; as there is no consonant (cluster) in the onset, [0] is realised as [h].

The relationship between aspiration and voicing is also apparent in a variant of the aspirate mutation, in which words beginning with "glides" (i.e. the semi-vowels /w/ and /j/) and the labial nasal are affected in the Bangor dialect:

(10.22)  
ei (h)laiθ  [i hjaɪθ]  'her language'
ei (h)waθ  [i hwəθ]  'her watch'
ei mab hi  [i məθə pi]  'her son'

However, although the transcription in (10.22) appears to imply that the semi-vowels are preaspirated (like the vowels in standard Welsh), this is contradicted by Griffen's statement (1975:185) that "/hj/ represents a palatal voiceless fricative and /hw/ represents a bilabial voiceless fricative (rounded)". Fynes-Clinton (1913:xviii), from whom the examples in (10.22) are taken, uses the symbols ç and y. However, he does not include these sounds in his set of 'spirants', but rather lists them with h, j, and w. "ç is the voiceless sound corresponding to j... y is the voiceless form of w". It seems appropriate, then, to characterise these segments as voiceless (aspirated) semi-vowels. Following Lass (1976), I assume further that prevocalic semi-vowels are liquids.

Notice, however, that whether we interpret these segments as
showing preaspiration or as being simply voiceless, they will have the same phonological representations, i.e. those in (10.23). The aspirate mutation of both the semi-vowels and the labial nasal involves increase in the |0|-ness of the representation:

(10.23) voiced semi-vowel $\rightarrow$ voiceless semi-vowel $V; V, C: 0 \rightarrow 0$

voiced nasal $\rightarrow$ voiceless nasal $V; C: 0 \rightarrow 0$

Phonetic realisation rules will determine whether the governing |0| is realised simultaneously with the representation of the categorial gesture (to give devoicing), or preceding it (to give preaspiration). I return directly to the exact status of the 'voiceless nasals'.

The nasal mutation process offers fewer problems. Awbery characterises the process simply as:

(10.24) $\{-\text{nas}\} \rightarrow \{+\text{nas}\} / \begin{array}{c} \text{[-cont]} \\ \text{[-liq]} \end{array}$

Thus, |b|, |d|, |ɡ| $\rightarrow$ /m/, /n/, /ŋ/, and |p|, |t|, |k| $\rightarrow$ /m/, /n/, /ŋ/.

Like spirant mutation, nasal mutation appears to involve an increase in |V|-ness, with no change in |0|-ness, as in (10.25):

(10.25) voiceless stop $\rightarrow$ voiceless nasal $0 \rightarrow 0$

voiced stop $\rightarrow$ voiced nasal $C; V: 0 \rightarrow V; C: 0$

However, it will be recalled that in §8.9 I argued that nasals are further distinguishable from other segment-types by the presence in the articulatory gesture of a component |n|, whose articulatory
correlate might be 'lowering of the velum'. Thus the segments resulting from the nasal mutation process will contain \( |n| \) in the articulatory gesture (together with the representations of the articulatory gesture characterising different places of articulation):

\[
\begin{align*}
(10.26) \text{ voiceless stop} & \rightarrow \text{ voiceless nasal} & 0 & \rightarrow 0.n \\
& & C & \rightarrow V;C \\
& \text{ voiced stop} & \rightarrow \text{ voiced nasal} & C;V:0 \rightarrow V;C:0.n
\end{align*}
\]

Thus, nasal mutation can be distinguished from the other mutations, as involving both an increase in \(|V|\)-ness, and the addition of the \(|n|\) component.

It is, however, appropriate to consider the so-called 'voiceless nasals' in rather more detail. Up to now, I have assumed that these segments are simply the voiceless counterparts of the normal voiced series. However, as is apparent from Griffen's transcriptions, it can also be claimed that these segments consist of a voiceless nasal segment followed by a period of aspiration (i.e. an '[h]'), while Awbery's transcriptions (/mh, nh, nh/) suggest a voiced nasal followed by /h/. Indeed, although Awbery has a rule which simply specifies the result of nasal mutation of a voiceless stop as [-voice], she notes that it "must undergo a specifying rule which segments out the voicelessness feature as an \( h \) segment". Scully (1973) shows experimentally that, at least in the speech of Awbery, the surface realisation of the nasal mutation of \( |t| \) is phonetically [nh], but argues that there are perceptual constraints determining the occurrence of this form; i.e. for the nasal mutation of \( |t| \) to be perceived as such, [nh] is a more appropriate form than [g]. This suggests that Awbery's approach is essentially correct; that is, phonologically [nh] is the 'voiceless equivalent' of [n], and should be characterised as a single segment which is [-voice]. In dependency terms, we again have a situation like those discussed in chapter 9. It seems that, phonologically, the governing \(|o|\) resulting from the application of nasal mutation has a prosodic status, as in (10.27):
where \( |0| \) has as its domain the syllable onset, consisting of a single segment. The 'specifying rules' will determine that, phonetically, \( |0| \) is sequentially distinct, as in (10.28):

The situation, then, is exactly parallel to the aspiration phenomena discussed in chapter 9.
Chapter 11
The Phonology of the Diminutive in Dutch

The second large scale phonological process which I wish to consider is one to which I have referred at various points in the preceding chapters - the behaviour of the diminutive suffix in Modern Dutch. This phenomenon has been extensively discussed in the literature: for general discussion, see, for example, Shetter (1959), and for discussion of phonological aspects, Cohen (1958), van Haeringen (1958), Moulton (1962), Haverkamp-Lubbers and Kooij (1971), Gussenhoven (1978), and van Zonneveld (1978), and, on aspects of its behaviour in non-standard dialects within the Netherlands, van den Berg (1975) on the dialect of Utrecht, Hoppenbrouwers (1978) on that of Westerhoven, and van Gurp (1979) and van Gurp and Ewen (ms) on that of Breda.

In this chapter I want to discuss in some detail a treatment of these phenomena within the phonological framework which has been developed in chapters 4-9. This will involve a rather detailed consideration of various aspects of the rules proposed by Haverkamp-Lubbers and Kooij (henceforth H & K), and by van Zonneveld. These rules are couched in a standard binary distinctive feature framework. The treatment here is largely based on that of Ewen (1978).

11.1 The data, and distinctive feature interpretations

Following Cohen (1958), H & K set up /tjə/ as the underlying phonological form of the diminutive suffix. However, the surface form of the suffix can have various realisations, the most important of which are [tjə], [ətjə], [jə], [pjə], [kjə]. The choice amongst these
realisations seems to be, in general, phonologically motivated, and the rules which H & K and van Zonneveld set up are concerned with accounting for these phonological regularities. I shall attempt to show that these rules, although observationally adequate, fail to explain the relationship between certain environments in which the same forms of the suffix are selected, and, further, fail to offer any explanation of why a particular suffix is chosen in a particular environment. This failure, I will suggest, is due to deficiencies in the distinctive feature framework, for reasons which I will discuss below.

My argument will concern principally those words which end in a nasal or a liquid, but it will be useful to look first at words ending in vowels and obstruents. If the last segment of a word is a vowel (whether it is a diphthong, a long vowel, or schwa), the form of the diminutive is [tie]. In addition, if the last segment is /w/ or /j/ (i.e., in H & K's terms, a glide (1971:14)), the form of the suffix is also [tje]:

(11.1) a. ui, uitje 'onion'
    partij, partijtje 'game'
    cadeau, cadeautje 'present'

    b. meew, meewtje 'seagull'
    konvooi, konvooitje 'convoy'

Van Zonneveld characterises this process as (11.2):

(11.2) \[ \text{DIM} + \begin{array}{c} \text{C} \text{ J} \text{ e} \text{ X} \text{ V} \\ \text{-son} \\ \text{+cor} \\ \text{-cont} \end{array} \]

(Notice that van Zonneveld does not work with the generative notion of the underlying form; hence the formulation in (11.2). I return to this below.)

If the last segment of a word is an obstruent, the form of the suffix is [Jə]:

(11.3) mand, mandje 'basket'
    maand, maandje 'month'
    jak, jakje 'jacket'
    fout, foutje 'mistake'
Van Zonneveld formulates the rule for obstruents as:

(11.4) $\text{DIM} \to \text{J} \in /X(C) \quad C \quad [-\text{son}]$

The situation in relation to the obstruents is, however, slightly more complex than the data in (11.3) suggests. If the last segment is /s/ or /t/, then palatalisation of this segment occurs (e.g. <gans> 'goose' $\to$ <gansje> /γanʃə/). This is clearly a low-level phonological rule, of which there seem to be several relevant to this area (H & K 1971:10-11, van Zonneveld 1978:282). Notice, too, that [je] is frequently realised as [i:], as in <jakkie>, <gekkie> 'strange person', <klompe> 'clog'.

In addition, some words ending in a short vowel followed by /p/, /b/ or /γ/, instead of deleting /t/ to give [jə], insert schwa to give [ætʃə]:

(11.5) pop, poppetje 'doll'
rib, ribbetje 'rib'
weg, wegetje 'way'
rug, ruggetje 'back'

These forms appear to be phonologically exceptional, and are treated as such by Cohen (1958:44), H & K (1971:10), and Gussenhoven (1978:211). (Notice, however, that there seems to be an increasing number of words following this pattern, especially after /γ/ --cf. in addition to the above, <vlag, vlaggetje> 'flag'.)

I turn now to the consideration of words ending in a nasal or liquid, i.e. the data presented in (1.16) above. For convenience I give the relevant data below. I consider first the monosyllabic forms:

(11.6) sjaal 'scarf'
deel 'part'
kool 'cabbage'
peul 'pod'
pijl 'arrow'
uil 'owl'
Paul (name)
$<-tje>$

blaar 'blister'
veer 'feather'
koor 'choir'
deur 'door'

$<-tje>$
raam 'window' maan 'moon' - 
zeem 'leather' teen 'toe' - 
boom 'tree' toon 'tone' - 
- steun 'support' - 
rijm 'rhyme' lijn 'line' - 
duim 'thumb' tuin 'garden' - 
- clown 'clown' - 

(-pje) (-tje)

(11.7) bal 'ball' kar 'cart' 
bel 'bell' ster 'star' 
tol 'top' tor 'beetle' 
spil 'pivot' - 
spul 'stuff' - 

(-etje) (-etje)

kam 'comb' pan 'pan' gang 'corridor' 
stem 'voice' pen 'pen' kreng 'bitch' 
bom 'bomb' bon 'ticket' gong 'gong' 
klim 'climb' spin 'spider' ring 'ring' 
gum 'rubber' bun 'basket' - 

(-etje) (-etje) (-etje)

(Notice that in the written forms of the first four columns in (11.7), the final consonant is doubled, e.g. <balletje>, <bonnetje>, etc. In the forms with <pje>, [jə] can be replaced by [iː], as in <duimpie>, <boompie>, etc.)

The Modern Dutch vowel system (see Moulton 1962:295-295) consists of:

(a) a set of vowels variously referred to as short (Moulton 1962:294), lax (H & K 1971:4), ongespannen (Cohen et al 1971:12), gedekte (van Haeringen 1958:159) - <a, e, i, u, o>.

(b) a set of vowels variously referred to as long (Moulton), tense (H & K), gespannen (Cohen et al, van Zonneveld 1978:284), ongedekte (Cohen), free (Moulton 1962:302) - <aa, ee, eu, o,o, i,e, uu, oe>.

(c) a set of diphthongs (tweeklanken - H & K 1971:2) - <ij (el), ui, ou (au)>.

(d) schwa.

(e) a set of 'foreign' vowels, which appear to behave in most respects like (b) - <e (è), eu, o> (<serre> 'conservatory', <freule> 'unmarried noble lady', <rose> 'pink').
(It will be seen from the above that (11.6) and (11.7) do not contain forms with the vowels <ie, uu, oe>, for reasons that will become apparent later. For a full account of the phonological and phonetic correlates of (a)-(e), see §11.3 below.)

From (11.6) and (11.7) we see that monosyllables containing a vowel followed by a single nasal or liquid take a surface diminutive <tje>, if the nasal or liquid is preceded by one of the vowels in classes (b) and (c) - i.e. a long vowel or diphthong - but <etje>, if the vowel is short (Cohen 1958:42-43, Moulton 1962:306-307, H & K 1971:5-6). Notice that after the long vowels and diphthongs, /tje/ becomes [pja] after the bilabial nasal (assuming the existence of an underlying form /tje/). On this assumption, then, /tje/ → [pja] is a low-level assimilation process, which is not relevant to the discussion here (but see below). Rather, I shall be concerned with the motivation for the choice between [tje] and [etje].

H & K assume an underlying form /tja/ for the diminutive suffix (as do, for example, Cohen 1958 and Gussenhoven 1978, while Hoppenbrouwers 1978, in his discussion of the dialect spoken in Westerhoven, takes as the underlying form /kə/ - the historical form from which the standard Dutch [tje] derives, and which still occurs as the form corresponding to [tje] in many dialects). H & K write a rule which will insert [ə] in the appropriate contexts to give the forms in (11.7), a rule which I give as (11.8):

\[
g → ə / [\begin{array}{c} V \\
{[-\text{tense}]} \\
{[\pm \text{son}]} \\
{[\pm \text{cons}]} \\
\end{array}] \quad \text{tj}
\]

Notice that the [+stress] specification is required to cater for polysyllabic words with stress on the final syllable:

(11.9) diagram, diagrammetje 'diagram'
wagón, wagónnetje 'wagon'
kólóm, kolómmetje 'column'
boerln, boerlnnetje 'farmer's wife'
konignln, koninglnnetje 'queen'
So, in the examples which we have looked at so far, [ə] is selected after a primary stressed syllable containing a short vowel followed by a nasal or a liquid, a situation characterised by van Zonneveld as:

\[
\text{(11.10)} \quad \text{DIM} \rightarrow \varepsilon \quad C \quad \text{j} \quad \varepsilon \quad X \quad V \quad C
\]
\[
[-\text{son}] \quad [-\text{tense}] \quad [+\text{son}] \quad [-\text{cont}]
\]

However, if a liquid appears between the short vowel and a nasal, as in (11.11), no [ə] is epenthesised (H & K 1971:10):

\[
\text{(11.11)}
\]
\[
zalm, \text{ zalmpje} \quad '\text{salmon}'
\]
\[
\text{helm, helmpje} \quad '\text{helmet}'
\]
\[
\text{worm, wormpje} \quad '\text{worm}'
\]
\[
\text{arm, armpje} \quad '\text{arm}'
\]
\[
\text{urn, urntje} \quad '\text{urn}'
\]
\[
\text{tarn, tarntje} \quad '\text{rip}'
\]

A problem arises with respect to the characterisation of (11.6) and (11.11) as a 'natural class'. The sequences form such a class, on the natural recurrence assumption (Anderson 1980), in showing lack of epenthesis of schwa. As H & K start off with an underlying form /tje/ (see above), it is not necessary for them to mention this particular set of forms in their rules - and the possibility of rule (11.8) applying to the forms in (11.11) is excluded by the fact that the lax vowel must \textit{immediately} precede the final nasal or liquid. However, the fact that they do not need to characterise the sequences long vowel + sonorant consonant, and short vowel + sonorant consonant + sonorant consonant as forming a natural class opposed to the sequence of short vowel + sonorant consonant arises from certain aspects of the theoretical framework within which they are operating - that of standard generative phonology. In particular, their model involves the setting up of a distinct underlying form for the diminutive suffix, and the derivation of all surface forms from this underlying form. However, it is possible to envisage a theory in which there is no unique underlying form for the diminutive suffix. Rather, in such a theory the selection of the diminutive suffix would depend on the surface form of the noun in question, and rules might (informally) be something like: if a word ends in a vowel, or in a long vowel + sonorant consonant, or in a short vowel + sonorant consonant + sonorant
consonant, then the form of the diminutive is [tjə]; if a word ends in a short vowel + sonorant consonant it is [ətjə], etc. Indeed, van Zonneveld suggests that this is the appropriate form of the rules (cf. (11.2), (11.4), (11.10)). The rules which he proposes, then, do not have underlying forms, and are to be read as:

Diminutief wordt . . ./ Kontekst. Dus: dit wordt dat
daar en daar.

[Diminutive becomes . . ./ Context, i.e. something be-
comes something else In such and such an environment.]

Van Zonneveld notes:

Er is voor verkleinwoordvorming een speciale oppervlakte-
regel, die ervoor zorgt dat -je altijd wordt voorafgegaan
door een echte medeklinker (= een obstruent, een niet
sonorante konsonant). Deze regel maakt aanname van de

[For diminutive formation there is a special surface rule
which ensures that -je is always preceded by a true con-
sonant (an obstruent, a non-sonorant consonant). This
rule makes the assumption of the underlying form /tjə/
unnecessary.]

Van Zonneveld's arguments against assuming that /tjə/, or in-
deed any other form, should be taken as the underlying form concern
principally the fact that this forces the use of "unmotivated assim-
ilation rules" in order to arrive at the correct surface form. Thus,
he claims (following Schultink 1974:28) that rules such as (11.12),
which Gussenhoven (1978:206) gives to derive for example, <raampje>
[raampja] from /raam+tja/ and <palinkje> [paliŋkja] from /palıŋ+tja/
are totally ad hoc, for two reasons:

(11.12) NASAL ASSIMILATION

\[ t + \begin{array}{l}
\text{acor} \\
\text{βant}
\end{array} / \begin{array}{l}
\text{acor} \\
\text{βant}
\end{array} + \begin{array}{l}
\text{nas} \\
\text{je}
\end{array} \text{ DIM} \]

Firstly, the assimilation process is progressive (stop assim-
lates to preceding nasal), while, according to Eijkman (1937), assi-
milation is usually regressive in Dutch. Secondly, van Zonneveld
argues that assimilation is usually an optional process, while rules
such as (11.12) must be applied to sequences such as /raam+tjə/; the
phonetic sequence *[raamtjə] is ill-formed in Dutch. I shall show
below that this kind of approach can be given a natural interpretation within dependency phonology, and I shall assume that in such a theory it would in fact be desirable to be able to specify the sequences ending in a sonorant which take [tʃe] as a natural class.

Within the feature system which H & K use, the following specifications would be required:

\[
\begin{align*}
(11.13) \text{a. } & \left\{ \begin{array}{c}
 V \\
 +\text{tense}
\end{array} \right\} \left\{ \begin{array}{c}
 +\text{son} \\
 +\text{cons}
\end{array} \right\} \text{ vs. c. } \left\{ \begin{array}{c}
 V \\
 -\text{tense}
\end{array} \right\} \left\{ \begin{array}{c}
 +\text{son} \\
 +\text{cons}
\end{array} \right\}
\end{align*}
\]

Notice the use of the brace notation (or 'curly brackets') in (11.13). It has been shown that there is no evidence suggesting that the use of these brackets in the characterisation of a natural class represents anything other than a deficiency in the system of phonological representation (Anderson 1977:75), in that such a formulation fails to show what is common to the two subparts (11.13a) and (11.13b). Thus, the componentiality assumption (Anderson 1980:166) is not met. It seems desirable, then, to try to eliminate these brackets from (11.13).

For van Zonneveld, this problem does not arise. He notes (1978: 295) that in the pronunciation of the words in (11.11) a schwa is pronounced between the two sonorants, i.e. [ərəm], [ərən], etc. On this interpretation, then, such words follow the same (phonetic) pattern as other bisyllabic words ending in a sonorant, such as <bezem, leven>, etc. However, it should be noted that it is not invariably the case that an epenthetic schwa appears in these words. Thus, it can be argued that phonologically, at least, these forms are monosyllabic, and may become bisyllabic by a (late) optional [ə]-epenthesis rule.

Whatever the solution to this problem, I shall show below that it is not crucial to a dependency interpretation, in that I shall claim that monosyllabic forms with a long vowel taking [tʃe] and
[pjal] share a common structure with bisyllabic words taking [tje], [pje], and [kjə], and that this structure is also apparent in the class of words in (11.11), whether or not they are interpreted as monosyllabic. At this point, however, we can only go some way towards showing this; a fully adequate account must wait until we have examined the dependency representations of these forms.

Returning to the difference between (11.13a) and (11.13b), then, and assuming the validity of the analysis of the forms in (11.11) as monosyllables, we see that the two appear to show a difference in the number of segments involved - (11.13a) contains two segments, and (11.13b) three. However, as we saw in chapter 7, Lass (1976: ch.1) has proposed that instead of a contrast between tense and lax vowels, as formulated in SPE, the difference between these two categories - i.e. between traditional long and short vowels - is one of geminate versus single vowels, represented as VV vs. V (see also, for Dutch, Moulton 1962:297). Adopting this approach, we can at least show that the same number of segments is involved in the two sequences in (11.6) and (11.11), as opposed to the structure of the forms in (11.7):

\[(11.14)\]  \(V [+\text{son}] [+\text{son} \text{+cons}] \) vs. \(V [+\text{son} \text{+cons}] \)

I return below to a solution of this problem which appears to throw more light on the distinction in (11.14), after considering the behaviour of the diminutives after non-primary stressed vowels followed by a nasal or liquid. We find the following forms which take <tje> (<pje>, <kje>):

\[(11.15)\]

- deksel 'lid'
- kachel 'stove'
- appel 'apple'
- dubbel 'double'
- handel 'handle'
- boezem 'bosom'
- Jochem (name)
- bezem 'broom'
- bodem 'bottom'
- Willem (name)

- traktor 'tractor'
- koffer 'suitcase'
- beker 'beaker'
- loper 'key'
- venster 'window'
- oven 'oven'
- tentamen 'test'
- eten 'food, meal'
- wagen 'car'
- leven 'life'

- ->tje
- ->pje
- ->tje
- ->pje
- ->tje
- <-tje
- <-tje
- <-tje
- <-kje
and the following which take <etje>:

(11.16) a. wandeling 'walk'
oefening 'exercise'
vergadering 'meeting'
herinnering 'memory'
onwikkeling 'development'

verzameling 'collection'
beginnelling 'novice'
zendeling 'missionary'
stedeling 'town-dweller'
vluchting 'refugee'

b. leerling 'pupil'
tweeling 'twin'
huurling 'mercenary'
naarling 'odious fellow'
kleurling 'coloured person'

It will be seen from (11.15) that, as in (11.6), the choice of <tje>, <pje>, or <kje> in these cases depends on the place of articulation of the preceding nasal or liquid (cf. Gussenhoven's nasal assimilation rule above). From now on I will use <Tje> and /Tje/ as cover-symbols for these forms.

Van Zonneveld offers the following rule to account for the forms in (11.15), together with those in (11.6), i.e. those which take /Tje/:

\[
\text{DIM } C \times X V C
\]
\[
\text{[+son]} \quad \{[+tense] \quad [+son] \quad \text{[acor]} \quad \text{[\=distrib]} \quad \{[\text{\=e}] \quad \text{[\=distrib]}
\]

(Notice again the need to use curly brackets; it is not immediately obvious why the long vowels of Dutch together with schwa should form a natural class opposed to all other short vowels.)

H & K devote some space to discussing the reasons for the difference between (11.15) and (11.16), and their final rule is meant to account for all cases of schwa-insertion:

(11.18)

\[
\varrho + \text{\=a} / \begin{cases}
\{[V] \quad +\text{cons} \quad [+\text{cons}] \quad t\}
\end{cases}
\]
\[
\{[V] \quad +\text{cons} \quad [+\text{cons}] \quad t\}
\]
The first line accounts for the forms in (11.7) and (11.9) (<kammetje, koninginnetje>), the second for forms in (11.16a) (<wandelingetje>), and the third for forms in (11.16b) (<leerlingetje>).

As H & K themselves point out, "een mooie regel is [(11.18)] niet" [(11.18) is not a beautiful rule], because of the use it makes of curly brackets. (11.18) scarcely seems to reflect a natural process in any sense. Moreover, it is observationally inadequate in at least one respect. H & K (1971:8) have to treat the form <teerling>, which has the diminutive <teerlinkje>, as irregular, as rule (11.18) would otherwise assign it the suffix <etje>. Similarly, for most speakers the diminutive of <tweeling> is <tweelingetje>, which is not predicted by the rule. (Notice, too, various other forms like <tweeling> - for example, <drieling> 'triplet', which take <etje>).

Recognising the inadequacy of (11.18), H & K offer (11.19) as a possible alternative:

(11.19) \[ g → e / [ V_{+str} ] \left[ +son \right] [+cons] \rightarrow t_j \]

where \[+str\] can be [1 stress], [2 stress], [3 stress]. (Notice that the vowel should, presumably, also be specified as [−tns], to exclude <maan, beer>, etc., which take <Tje>.) For rule (11.19) to apply correctly, H & K need a rule which will place stress on the final syllable of the relevant words in (11.16). The first rule which does this is (11.20):

(11.20) \[-str \rightarrow [+str] / [ V_{+str} ] C_1 \in C_1 \left[ V \right]\]

\(<\text{wandeling} \rightarrow 1\text{wandeling}, \text{while zending}' \text{dispatch}' \text{remains } 1\text{zending}\>.

It seems quite reasonable to assume that the last syllable of <wandeling> has more stress than the second - this corresponds with the intuitions of native speakers. Whether this syllable should be treated as having specifically tertiary stress is, however, not at all clear.
(11.20), then, removes the need for the specification of the top line of the first disjunction of (11.18). To account for forms characterised by the second line of this disjunction, H & K note that some rule must place \[3 \text{stress}\] on the final syllable of the words in (11.16b), to give \(<\text{leerling}, \text{huurling}>\), etc. This rule will presumably have (11.21) as its environment:

(11.21) \[
\begin{array}{c}
V \\
+\text{tns} \\
+\text{str} \\
+\text{son} \\
+\text{cons} \\
+\text{voc} \\
+\text{cons} \\
\end{array}
\]

H & K's rule will undoubtedly yield the correct outputs (with the exception of forms like \(<\text{teerlinkje}>\) and \(<\text{tweelingetje}>\), whose apparently exceptional status is not affected by the change in the rule). However, there are still some problems. The implication of (11.21) is clearly that the second syllable in words like \(<\text{huurling}>\) and \(<\text{kleurling}>\) is more stressed than the second syllable in words like \(<\text{vorming}>\) and \(<\text{helling}>\). As noted in §7.3, I have been unable to find support from native speakers for this point of view. If this is the case - that there is in fact no psychologically real distinction - then all that these 'stress-assignment' rules are doing is placing a diacritic on the appropriate forms to make them meet the SD for rule (11.19), which will provide them with the appropriate diminutive suffix. I suggest that there is in fact no genuine phonological reason for distinguishing classes (11.15) and (11.16b), and that what H & K are doing is trying to 'phonologise' the data on insufficient grounds.

This, however, does not mean that we have to mark the difference in the behaviour of the two classes in the lexical entries for the individual words. Consider the various items ending in \(<\text{ling}>:\n
(11.22) stelling 'proposition'
wandeling 'walk'
afdeling 'department'
verzameling 'collection'
paling 'eel'
ontwikkeling 'development'
teerling 'die'
handeling 'transaction'
Irrespective of their phonological structure, words ending in <ling> can be divided into two categories ((11.22) and (11.23)). All the words in (11.23) contain the morphemic suffix LING, among whose semantic features is [+human], according to van Zonneveld, or 'member of a group', according to Gussenhoven. The latter definition is perhaps the better, in view of the existence of forms such as <groenling> 'greenfinch', which has the diminutive <groenlingetje>. The words in (11.22), however, do not contain this morpheme. Rather, they are generally derived from a verb +ING (e.g. <stelling> ~ stelling, <wandelen> ~ wandeling), or are monomorphemic (<paling>, or <teerling>, which, as H & K point out (1971:22), is derived historically from <teerlink>). All words containing LING take the <etje> form of the diminutive suffix, whatever their phonological structure. Given this fact, there are two possible ways of deriving the appropriate suffix. We can either claim that the LING suffix is assigned tertiary stress - that is, we can have a phonological rule making reference to a morphological category - or we can have a morphological rule which simply states that the form of the diminutive after LING is <etje> - that is, this is a morphological fact about Dutch. I have already noted that I can find no evidence that, for example, <leerling> has a different stress-pattern than <stelling>, and so I adopt the latter solution, that the form of the diminutive after the morpheme LING is morphologically determined. Notice that this solution deals with the apparent irregularity of <tweeling>, which will take the diminutive <tweeling-etje> by regular morphological rule.

Interestingly, van Zonneveld offers a virtually identical interpretation, claiming (1978:286):

De isolering van de ling-afleidingen laat zich echter wel rechtvaardigen: woorden als leerling, eenling moeten ling-vormen zijn, omdat leerl en eenl geen grondwoord
kunnen zijn. Semantisch hebben ling-woorden gemeen dat het aanduidingen voor personen zijn, wat niet het geval hoeft te zijn bij ing-woorden.

[The isolation of ling-suffixes is, however, justifiable: words such as leerling, eenling 'individual' must be ling-forms, because leerl and eenl cannot be radicals. Semantically, ling-words have in common that they refer to persons; this is not necessarily the case with ing-words.]

Van Zonneveld's rule for the LING forms is:

\[(11.24) \ DIM + [C] / [X (a)] + [ling] \]

while Gussenhoven (1978:210) notes:

De oplossing lijkt hier te zijn dat het morfeem ling ('lid van een groep') een [a] krijgt onafhankelijk van waarmee het gekombineerd wordt. Tweeling en leerling bevatten beide dit morfeem: speeling is uiteraard speel + ing en teerling is monomorfematisch.

[The solution here seems to be that the morpheme ling ('member of a group') takes [a] irrespective of what it is combined with. Tweeling and leerling both contain this morpheme: speeling 'tolerance' is of course speel + ing and teerling is monomorphemic.]

Let us return to the class of items in (11.22). This class can be subdivided into those words which take <tje>, and those which take <etje>. The first set corresponds to that in (11.15), while the members of the second set all contain the structure illustrated by the SD of (11.20) - i.e. they all have a schwa preceding the final syllable. The two classes are illustrated in (11.25) and (11.26):

\[(11.25) \ \text{deksel traktor boezem oven vorming} \]
\[\ \text{appel beker bezem eten teerling} \]
\[\ <-tje> <-tje> <-pje> <-tje> <-kje> \]

\[(11.26) \ \text{wandeling verzameling handeling} \]
\[\ \text{ontwikkeling herinnering oefening} \]
\[\ <-etje> \]

Clearly, we can distinguish phonologically between these two categories. One way of making this distinction would be to adopt
H & K's idea that the final syllable of (11.26) has [3 stress] and that of (11.25) is unstressed([-stress]). However, because this relies on making a direct comparison between the stress of syllables in different lexical items in isolation, it is better to consider that in (11.25) the final syllable immediately follows the primary stressed syllable, while in (11.26) the final syllable immediately follows a syllable which is less stressed than the final syllable, and which itself immediately follows the primary stressed syllable. We have already seen that there is no support among native speakers for the view that words like <leerling> and <stelling> have different degrees of stress on their final syllables, and exactly the same applies to a comparison between the final syllables of, say, <vorming> in (11.25) and <oefening> in (11.26). The comparison of degrees of stress of different lexical items in isolation, then, is something that appears to be difficult for native speakers, and I suggest that it is better for phonological rules to make reference to comparative degrees of stress within a single lexical item, rather than to have to make judgments as to the relative stress of syllables in different lexical items. In other words, stress, as noted in §7.3, is a combinatorial, and therefore relative, rather than an absolute property.

A similar solution is offered by Gussenhoven (1978), who, following van den Berg (1975), suggests that some sort of 'rhythmic principle' is involved. If the final syllable has greater 'sonority' than the penultimate, or, in other words, is 'rhythmically stronger', then schwa insertion will take place.

Whichever of these solutions we adopt, notice that <teerling> is automatically assigned the correct diminutive - <teerlinkje> - and so is no longer an exception. However, <pippeling> 'pippin', which, according to H & K (1971:8), has the diminutive <pippelinkje>, is irregular in all the solutions which I have discussed. (I have found, though, that it is very difficult to get any native speaker reaction at all to this word - it seems to be virtually unknown to the speakers I have consulted. In addition, speakers who have heard the word tend to produce the expected diminutive <pippelingetje>.)
It is interesting to note that a few speakers have the form <tweelinkje>, rather than the expected <tweelingetje>. This is presumably explicable by a conflict between, on the one hand, the regular phonological rule which characterises the forms in (11.25), and, on the other, the morphological categorisation of <tweeling>. It seems likely that for some speakers there can be confusion between the two factors, and <tweeling> would be a very likely candidate for this confusion, because there are few words with the LING suffix which have a vowel immediately preceding the LING, while on the other hand there are many words belonging to the class in (11.25) which contain the sequence <V+ling>. Similarly, a few speakers have the form <teerlingetje>, presumably because of an incorrect morphological categorisation - again conflict between the two factors involved.

Rules (11.18) and (11.19) can now be rewritten as:

\[(11.27) \quad \text{if } a \text{ then } b\]

while van Zonneveld provides the following rules for the forms in (11.25) and (11.26):

\[(11.28) \quad \text{DIM } \rightarrow \quad \text{C } \quad \text{J } \epsilon / X \quad C_1 \quad (+) \quad [\text{ing}] \quad \text{Condition: X does not end in schwa.}\]

\[(11.29) \quad \text{DIM } \rightarrow \quad \text{C } \quad \text{J } \epsilon / X \quad a \quad C_1 \quad + [\text{ing}] \quad \text{[+cor]}\]

Gussenhoven's rule for schwa insertion, however, is rather differently formulated:

\[(11.30) \quad \text{if } a, \text{ then } b\]
In other words, \[\text{a}\] is inserted if the stem-final consonant is \([l, r, m, n, \eta]\) and the preceding vowel is lax; in a stem of more than one syllable the penult cannot be stressed, and if the final syllable contains \([i]\), then the penult must contain \([a]\).

Gussenhoven interprets \([a]\) as neither lax nor tense.

Thus, Gussenhoven's rule is formulated so that the crucial factor determining schwa insertion is the lack of stress on the penultimate syllable of non-syllabic words. He also notes the existence of a set of forms which require the insertion of the material in angle brackets in (11.30), i.e. those in (11.31):

(11.31) kriterium, kriteriumpje 'criterion'
terrarium, terrariumpje 'terrarium'
beoordeling, beoordelinkje 'judgement'
tonzenuwking, ontzenuwinkje 'enervation'

These words have primary stress on the antepenultimate syllable, like <wandeling>, but unlike <wandeling>, have a diminutive in <Tje>, rather than <etje>. In the cases in (11.31), Gussenhoven claims that the last syllable is not rhythmically strong, unlike the last syllable in <wandeling>. The conditions which he formulates for the final syllable to be rhythmically strong, and hence to take an <etje> diminutive are the following: 1) it has primary stress or 2) the antepenult has primary stress and a) the final syllable contains \([i]\) and the penult \([a]\) or b) the final syllable does not contain \([i]\) or \([a]\).

Case 1) covers <kar> and <balkon> 'balcony', and case 2a) <wandeling> - while 2b) excludes, for example, <beoordeling>. I return below to what seems a more natural interpretation of the forms in (11.31).

All of the rules (11.27) - (11.30) more or less achieve observational adequacy. A question which arises, however, is whether they reflect any degree of similarity between the members of each of the two classes which behave in different ways in relation to diminutive formation. That is, do they fulfil the componentiality assumption?
I suggest that they do not. For example, in H & K's model, the class of forms which take <etje> is shown by the SD of (11.27), while those that take <Tje> can be characterised as (11.32):

(11.32) \[
\begin{align*}
&\begin{cases}
  V \\
  +\text{tns} \\
  +\text{str}
\end{cases} \\
&\begin{cases}
  V \\
  +\text{str} \\
  +\text{son} \\
  +\text{cons}
\end{cases}
\end{align*}
\]

\begin{align*}
&\begin{cases}
  V \\
  +\text{str} \\
  +\text{cons} \\
  -\text{tns}
\end{cases}
\end{align*}

(maan) 

(urn) 

(deksel, woning)

11.2 A dependency interpretation

It is difficult to see how either (11.27) or (11.31) represents a natural class. Notice yet again that both classes require the use of curly brackets. I suggest that this is not due to any particular defect in the formulation of (11.27) and (11.31) (or indeed of any other of the various rules which have been discussed above), but rather is due to "a deficiency in other aspects of the notation: specifically, its failure to characterises the structure of syllables and clusters" (Anderson 1977:67-68).

Some of these problems can be overcome by interpreting the data in terms of the dependency model. Consider first monosyllables ending in a liquid or a nasal - i.e. the sequences characterised in (11.13) and (11.14):

(11.33) 

\[
\begin{align*}
V_a & \quad V_a \\
V & \quad V_b \\
C & \quad C
\end{align*}
\]

maan
There is a very obvious way of characterising (11.33) and (11.34) as a natural class distinct from (11.35). In (11.33) and (11.34) (assuming for the moment: that forms such as <urn> are monosyllabic), we find the sub-structure shown in (11.36):

\[(11.36) \quad V \quad V \quad V \quad C\]

i.e. a structure in which \(|V| \neq |V| \neq |V = C|\); (11.35), however, does not contain this structure. We do not require the use of curly brackets in order to establish the natural class represented by (11.36) - rather, the fact that the sequence vowel + vowel + sonorant consonant behaves in some sense in the same way as the sequence vowel + sonorant consonant + sonorant consonant follows naturally from the representations for the categorial gesture set up in chapter 6. We can replace (11.13) and (11.14) by (11.37):

\[(11.37) \quad V \quad V \quad V \quad C\]
Thus the representations established for the categorial gesture allow us to show the difference between the two classes in an obvious way.

Can we establish the same pattern for polysyllabic words? Consider first of all those forms which do not take an epenthetic [ə] before /Tje/ - i.e. those represented by the bottom line of (11.32):

(11.38)

```
(11.38) V a  
    \   /  
   Va   Vb
   \   /  
    S   S  
```

woning

(11.39)

```
(11.39) V a  
    \   /  
   Vd   Vb
   \   /  
    S   S  
```

scheiding

(11.40)

```
(11.40) V a  
    \   /  
   Vb   Vc
   \   /  
    S   S  
```

deksel

Notice that in this chapter I employ representations of the type in (11.38) - (11.40), i.e. those with simple labelled nodes, in which
relative dependency of syllabics is characterised by the relative vertical placement of such labelled nodes. This is merely a notational convenience; it will be seen that the expression of the natural recurrent sequences involved is facilitated by the use of such structures rather than the more complex (but essentially notationally equivalent) trees generally used in the preceding chapters.

In all the cases in (11.38) - (11.40), we find the structure $|V_a| \oplus |V_b| \oplus |V_c = (V), C|$, with the possibility of a further $|V|$ (either $|V_d|$ or another $|V_a|$) intervening between $|V_a|$ and $|V_b|$. Crucially, however, all polysyllabic words ending in a nasal or a liquid which take <Tje> as the diminutive suffix contain the structure $|V| \oplus |V| \oplus |V=C|$. This structure, of course, is exactly the same as that for the monosyllabic forms which take <Tje>. Notice, too, that if we accept van Zonneveld's claim that <urn, arm>, etc., are bisyllabic, we again have the same structure:

(11.41) \[
\begin{tikzpicture}
  \node (V_a) at (0,0) [text height=2em] {urn};
  \node (V_b) at (1,0) [text height=2em] {\_} edge from parent node[anchor=west] {S};
  \node (V_c) at (2,0) [text height=2em] {\_} edge from parent node[anchor=west] {S};
  \node (V) at (3,0) [text height=2em] {\_} edge from parent node[anchor=west] {S};
  \node (V) at (4,0) [text height=2em] {\_} edge from parent node[anchor=west] {S};
\end{tikzpicture}
\]

(11.42) and (11.43) represent polysyllabic words which take <etje>:

(11.42) \[
\begin{tikzpicture}
  \node (V_a) at (0,0) [text height=2em] {\_} edge from parent node[anchor=west] {S};
  \node (V_b) at (1,0) [text height=2em] {\_} edge from parent node[anchor=west] {S};
  \node (V_d) at (2,0) [text height=2em] {\_} edge from parent node[anchor=west] {S};
  \node (V_c) at (3,0) [text height=2em] {\_} edge from parent node[anchor=west] {S};
\end{tikzpicture}
\]

\text{wandel}
The difference between the representations of polysyllabic structures taking <etje> and the representations of those that do not is not immediately clear. Both appear to contain the structure:

\[(11.44) \ V_a \rightarrow V_b \rightarrow V_c \rightarrow (V),C\]

Crucially, however, in (11.42) and (11.43) there intervenes an additional \(|\ V|\) between \(|V_a|\) and \(|V_b|\), i.e. \(|V_d|\), which is dependent on both \(|V_a|\) and \(|V_b|\). The presence of this dependent \(|V|\)-node appears to ensure that the word in question takes <etje>. Notice that if this node precedes \(|V_a|\), the word is not affected, as in <bedoeling>, which takes <Tje>:

\[(11.45) \ V_a \rightarrow V_d \rightarrow V_b \rightarrow V_c \rightarrow \text{bedoeling}\]
(For simplicity, I treat \(|V_a|\) as being short - see below for further discussion of the status of such vowels.)

The constraint which appears to be operating, then, is this: if, between the primary stressed vowel and the final vowel, there intervenes a vowel with lower stress than the final vowel (i.e. a vowel which is dependent on the final vowel), then the selection of the diminutive suffix is made on the basis of the structure beginning with the final vowel. Rather more generally, diminutive selection depends on the structure beginning with the last vowel in the item which has another vowel preceding and directly dependent on it. If there is no such vowel, the primary stressed vowel is the relevant one. With respect to (11.42) and (11.43), then, diminutive selection proceeds from \(|V_b|\), as \(|V_d|\) both precedes it and is directly dependent on it. (Notice that in (11.45), \(|V_d|\) precedes \(|V_b|\), but is not directly dependent on it.) The structure which is relevant to the selection of the diminutive in (11.42) and (11.43) is, then, simply:

\[
(11.46) \quad V_b \quad \leftarrow \quad V_c \quad \leftarrow \quad C
\]

The structure in (11.46) is exactly the same as that for <man> in (11.37b), and so the diminutive suffix is the regular <etje> form.

I have assumed throughout that anything which precedes the primary stressed syllable is irrelevant to the application of the diminutive rules. In view of the preceding discussion, we see that the status of a vowel preceding the primary stressed syllable is exactly the same as that of \(|V_d|\) in (11.42) and (11.43). This is evident in the following examples:

\[
(11.47) \quad \text{verhaal} \quad \text{'story'} \quad \text{herhaling} \quad \text{'repetition'}
\]

\[
\text{retour} \quad \text{'return'} \quad \text{ontsteking} \quad \text{'Infection'}
\]

\[
<-Tje> \quad <-Tje>
\]
Within the dependency model, it seems that forms such as *beoordeling*, *beoordelinkje* and *criterium*, *criteriumpje* cited by Gussenhoven do not have to be treated as exceptional. What is crucial here is the relative prominence of the last two syllables; if the final syllable governs the penultimate syllable, then such words must be marked as exceptional with respect to diminutive formation. However, it is not clear that this is the case; in words such as *beoordeling*, native speakers tend to think that the penultimate syllable is more stressed than the final syllable, thus giving:

(11.48) beoordeling

\[
\begin{array}{c}
V_a \\
\uparrow \\
V_{e} \\
\uparrow \\
S \\
\uparrow \\
S \\
\uparrow \\
S \\
\uparrow \\
S \\
\uparrow \\
V_{b} \\
\uparrow \\
V_{c} \\
\uparrow \\
V_{d} \\
\uparrow \\
C \\
\end{array}
\]

in which the \(|V| \neq |V| \neq |V = C|\) structure is apparent, and hence *Tje* is the regular suffix. I presume, indeed, that the presence of a non-reduced vowel in the penultimate syllable of such words may be a reflection of the fact that \(|V_b|\) is more prominent than \(|V_C|\). Notice too that in (11.48) /1/ is ambisyllabic, while in forms like *wandeling* we do not find post-stress ambisyllabicity for /1/.

For cases such as *criterium*, however, things are not so straightforward. Speakers either state that the last two syllables are equally stressed, or that the <i> represents a semi-vowel; i.e. *criterium* is trisyllabic. In this case, the structure would be:
(where prevocalic \([i]\) is interpreted as a semi-vowel). If (11.49) is an appropriate representation, diminutive selection is again regular; however, further investigation of these forms is required.

A final example of some interest is the following. The word <gom> 'gum', as we would expect, takes the diminutive <gommetje>. However, the compound <kauwgom> 'chewing gum' has, for many speakers, the diminutive <kauwgompje> (cf. van Zonneveld 1978:284). The structures involved are:

(11.50)  
\[
\begin{array}{c}
V_a \\
S \\
V_b \\
C
\end{array}
\]

(11.51)  
\[
\begin{array}{c}
V_a \\
V_d \\
S \\
S \\
V_b \\
V_c \\
C
\end{array}
\]

The reason for the difference is clear. In (11.50) we find the regular structure for <etje> selection, while in (11.51) <gom> occurs
as part of a larger structure in which we find the regular configuration for <Tje> selection. Notice, however, that some compounds do not show this behaviour. Gussenhoven, for example, cites <boktor, boktor-retje> 'longhorn beetle' and <bisdom, bisdommetje> 'diocesè'.

We have arrived at a much more natural and simple specification of the natural classes involved than was possible in a distinctive feature framework. (11.32) - containing a three-part disjunction - is replaced by (11.52), which characterises all sequences ending in a sonorant consonant which take <Tje>:

(11.52) \[
\begin{array}{c}
V \\
C \\
V \\
(V) \\
(V)
\end{array}
\]

while (11.53), which characterises all such sequences which take <etje>, replaces (11.27), which also contains a disjunction:

(11.53) \[
\begin{array}{c}
V \\
C \\
V \\
(V) \\
(V)
\end{array}
\]

Notice that, in arriving at this generalisation, we have made use both of the representations of the categorial gesture, and of the characterisation of the notions of stress and syllabicity within the dependency framework.

11.3 The <ie, wu, oe> problem

An interesting set of words in Dutch can take either <Tje> or <etje>, as, for example, those in (11.54):
As van Haeringen (1958:163) and Moulton (1962:306-307) observe, these alternative forms occur only in words with the vowels <ie, uu, oe>. (These were just the vowels which were omitted in (11.6) and (11.7).) In Modern Dutch, these vowels, historically derived from long vowels (Moulton 1962:310), are anomalous, in that they behave distributionally in the main like long vowels, but are phonetically short in all contexts except before /r/. (For discussion of these vowels, see van Haeringen 1958, Heeroma 1959.) In H & K's terms (1971:9), these vowels are neither long nor short ("noch lang, noch kort"). Most words containing these vowels have diminutives only in <Tje> (<riem, riempje 'belt', <tien> 'ten' ~ <tientje> 'ten guilder note', <molekuul, molekuultje 'molecule'). However, Moulton (1962:307) claims that "the patterning as checked vowels is clearly on the increase", because new formations always take <etje>, not <Tje> (<pseudoniem, pseudoniem-etje 'pseudonym', <de Bloemetjes> and <de Priemetjes> (children of <Bloem> and <Priem>)). It is, however, difficult to obtain unambiguous confirmation of this view from native speakers - they appear to have difficulty in accepting as 'correct' many of the forms in <etje> given by van Haeringen, Heeroma, and Moulton. Nevertheless, it is clear that it is only these three vowels which show this anomalous behaviour. Moulton (1962:308-310) suggests a possible phonemic solution to this problem. He suggests that these are the only vowels in Dutch which do not participate in a phonemic long-short opposition:

The second "novel aspect" of this analysis is that "i, u, o are structurally the short correlates of ee, eu, oo" (1962:310) - an analysis which bears a striking resemblance to that proposed for the Middle English vowel system by Anderson and Jones (1977:154). We can display Moulton's system as (11.55) (taking long vowels to be geminates):
(11.55) [i]/[iː]  
/ɪ(ɪ)/  
<ie>

[ʊ]/[ʊ:]
/ʊ(ʊ)/  
<u>

[u]/[uː]
/ʊ(ʊ)/  
<oe>

[ɛ]/[ɛː]  
/ɛ(ɛ)/  
<ee>

[ɛ]/[ɛː]  
/e(ɛ)/  
<ee>

[ɔ]/[ɔː]  
/o(ɔ)/  
<oo>

[œ]/[œː]  
/o(œ)/  
<oo>

[æ]/[æː]  
/a(a)/  
<aa>

<eɪ>/[eɪ]
<bracketed vowels in (11.55) are the foreign vowels of class e.)

However, in a phonology which recognised a lexical level of representation, the vowels <ie, uu, oe> would presumably be long at this level. By a phonological rule, the long vowels underlying <ie, uu, oe> will be converted into short vowels everywhere except before /r/. A problem which arises in such a framework is the ordering of this rule with respect to the rule determining the form of the diminutive suffix. If the diminutive rule applies before the shortening rule, then forms like <bloem> and <wiel> would be assigned the diminutives <bloempje> and <wieltje> - i.e. the regular forms for words containing long vowels. If, however, the rules are in the reverse order, then the diminutives would be <bloemetje, wieletje>, etc. - the regular forms for words containing short vowels. One possibility would be to allow the diminutive rule to apply both before and after the shortening rule, so that both forms can be generated. This is clearly an ad hoc solution, but, within a framework which recognises the existence of underlying forms, the problem must be dealt with in some way. H & K (1971:13) characterise these segments as being unspecified for the feature [tense] (the feature which distinguishes long vowels from short vowels). This, however, raises certain difficulties. It is not
clear whether they envisage a rule to assign a value (+ or -) to segments marked as [0 tense]. If so, they face the same problem of the relative ordering of the diminutive rule and a rule changing [+tense] vowels into [-tense] in these items. If they do not have such a rule, then [0 tense] is functioning as a third value, in that segments with the value [0 tense] would optionally undergo the [ə]-epenthesis rule. This would be a clear violation of the principle that [0] cannot function as a third value in a binary distinctive feature phonology (Stanley 1967:410, Brown 1970:14). These arguments, then, tend to lend support to the point of view that the diminutive should not necessarily be derived from a single underlying form, but that selection of the suffix should instead be sensitive only to the surface shape of the stem, as argued above and by van Zonneveld.

Within the dependency model, an interpretation of the anomalous status of the high vowels can be offered, using the representations of the articulatory gesture established in chapter 8. (11.56) is a possible representation of Moulton's phonemic analysis of Dutch, assuming that the shortening of <ie, uu, oe> has not yet operated:

(11.56) a. <ie> i, i, <uu> l, u, <oe> u, u

<ee> i, a, i, a, <eu> i, u, a, i, u, a, <oo> u, a, u, a

(<a>) i, a, (<eu>) i, u, a, (<oo>) u, a, u, a

<aa> a, a

<ei> i, a, <ui> i, u, a, <ou> u, a, <au> u, u
397.

b. <i> i;a <u> i,u;a <o> u;a
<e> i:a <o> u:a
<a> a

(/ə/ will be characterised as |ə|).

After shortening of the three high vowels, the short vowel system becomes:

(11.57) <ie> i <uu> i,u <oe> u
        <i> i;a <u> i,u;a <u> u;a
        <e> i:a <o> u:a
        <a> a

If we adopt the view that diminutive selection is sensitive to the surface form of the stem, as argued by van Zonneveld, we must explain why just {i|}, {i,u|}, and {u|} can take either <Tje> or <etje>.

Anderson and Jones establish a strength hierarchy for the basic vocalic elements (1977:123ff):

(11.58) a a u i

wherein the direction of the arrow is towards increasing strength. Strength is in this case manifested mainly in ability to effect mutation or diphthongization.

Further, they claim, long vowels are inherently stronger than short vowels.

If we examine the forms that can take <Tje> and <etje>, we see that these are the only short vowels (after the operation of the shortening rule) which do not contain the basic element [a] - i.e. they all contain either or both of the two strongest elements (|i| and |u|). Thus, {i|}, {i,u|}, and {u|} are the strongest of the short vowels.

A possible explanation for the status of these vowels with re-
spect to diminutive assignment is the following. On the one hand, they can take <etje> because they are phonetically short, and may therefore pattern with the short vowels; on the other hand, they can take <Tje> because, in terms of strength, they are more like the long vowels than any of the other short vowels. And, in fact, this may explain (synchronically) why they show this dichotomy in general — i.e. why they are like long vowels distributionally, but like short vowels phonetically — and not only in relation to the diminutive process.

The advantage of this interpretation of the behaviour of these forms is that it does away with the need for a possible double application of the rule for diminutive selection in a phonology which recognised the existence of an underlying form for the diminutive suffix; a rule which would only be relevant to an apparently idiosyncratic subset of vowels, or for the marking of this subset as being irregular with respect not only to the diminutive rule, but to various other processes in the language. Rather, we need a diminutive rule which is sensitive to the strength of the upper vowel in (11.53). Notice finally that before /r/, <ie, uu, oe> are always phonetically long, and permit only <Tje> diminutives (<bier, biertje> 'beer', <buur, buurtje> 'neighbour', <boer, boertje> 'farmer'). For these forms, of course, the vowel remains long, and so the rules will assign the regular diminutive form for words containing long vowels.

11.4 Canonical configurations in Dutch

I have shown that the difference between words with <Tje> diminutives and words with diminutives in <etje> can be naturally captured by the difference between the dependency structures in (11.52) and (11.53). However, why should there be just this difference? That is, what is it about (11.53) that causes the epenthesis of schwa?

Anderson and Jones (1977:ch.6) discuss the notion of 'canonical configurations' — i.e. surface 'shapes' (in terms of dependency structures) which are in some way 'preferred' at a particular stage of a
language (see also Jones 1977). In particular, they are concerned to show the possible equivalence of sequences such as $V + V + C$, $V + C$ (= sonorant), and $V + C + V$ as manifestations of such a configuration (cf. also Lass and Anderson 1975:270).

The notion of canonical configurations can be applied to the behaviour of the diminutive in Dutch. As we have seen, those forms which take <Tje> all have a structure in which two $|V|$s are dependent on the governing $|V|$ of the structure. In words which take <etje>, this condition is not fulfilled. However, the effect of epenthesising [ə] is to create a structure like (11.59) (in which the [tje] itself is excluded):

(11.59)

```
  V
 /\  \
Va /  \VC
   /  \
S   Vb
   /  \
  m  C nn e
```

(11.59) is a structure in which we find an epenthetic $|V_C|$ which is dependent on $|V_a|$. As a result, $|V_a|$ now has two $|V|$s dependent on it. The epenthesing of [ə], then, creates a configuration which is equivalent to the configurations which take <Tje>. If we look now at (11.60), which shows the four different structures involved, we find:

(11.60) a. *maan(tje)*

```
  VVC
 /\ /\  \
 V_a /  \  \
 /  \
Va /  \
  m  C nn e
```

b. *urn(tje)*

```
  VCC
 /\ /\  \
 V_a /  \  \
 /  \
Va /  \
  m  C nn e
```

(11.60) a. *maan(tje)*

```
  VVC
 /\ /\  \
 V_a /  \  \
 /  \
Va /  \
  m  C nn e
```

b. *urn(tje)*

```
  VCC
 /\ /\  \
 V_a /  \  \
 /  \
Va /  \
  m  C nn e
```
In (11.60), we see that all of the structures contain a configuration in which $|V_a| \neq |V_b|$ and $|V_a| \neq |V_c|$ (where $|V_a|$ and $|V_b|$ may be identical). Notice, too, that the kind of sequences which are shown by (11.60) to be in some sense equivalent are just those which Anderson and Jones and Lass and Anderson were also concerned with.

We can say that for the addition of <Tje> as the diminutive suffix, the canonical configuration is one in which two $|V|$s are dependent on the governing $|V|$, and if this configuration is not met, a schwa is epenthesised so that the canonical configuration is created. Without the kind of dependency structures used here, it is impossible to incorporate this kind of notion into phonological representations. Notice that van Zonneveld, too, observes that in the explanation of [ə]-insertion, appeal has been made to "rhythmic factors"; presumably, then, [VyCatjə] is rhythmically equivalent to [VCTjə].

Thus, the introduction of the notion of canonical configuration lends support to the claim that it is the surface shape of the stem that determines the choice of the diminutive suffix.

Another class of words selects <tje> - those ending in a vowel:

(11.61) uî, uitje 'onion'
zee, zeetje 'sea'

The structures involved are:
These configurations involve the structure:

\[ (11.64) \quad V \quad V \]

rather than that in (11.52) - i.e. they only contain two \( |V| \)s, not three. However, they also differ from (11.53), in that they do not contain a \( |C| \) subjoined to the dependent \( |V| \). Anderson and Jones (1977:157) show that the 'Vowel Strengthening Schema' in English has as its scope structures like (11.64) as well as structures like (11.52). In other words, the structure in (11.64) appears to be equivalent in strength to the structures in (11.60). This seems quite reasonable, in that with respect to single segments, the more prominent the \( |V| \), and, correspondingly, the less prominent the \( |C| \), then the more \( |V| \)-like the segment becomes. Similarly, from a configurational point of view, we can argue that in (11.60) the extra \( |V| \) is required to 'make up' for the presence of \( |C| \), while in (11.62) and (11.63), where the \( |C| \) is absent, the configuration is already sufficiently \( |V| \)-like.

Further support for the validity of the claim that (11.60) represents some kind of canonical configuration in Dutch can be found in the behaviour of comparatives of adjectives ending in /r/ (but not in /l/ or a nasal). Many dictionaries give the comparative suffix of all such adjectives as <der> ([d@r]). The normal form of the comparative suffix in Dutch is <er> ([er]), and so these forms show an epenthetic [d]. However, for many speakers, I have found that this is not true of all adjectives ending in /r/. Rather, for these speakers, no [d] is epenthesis ed following a short stressed vowel. These speakers, then, have the following forms:
(11.65) starrer 'stiffer'  
schorrer 'hoarser'  
bizarer 'more bizarre'

(11.66) duurder 'dearer'  
zeerder 'sorer'  
teerder 'more tender'

(11.67) lekkerder 'nicer'  
zekerder 'more sure'  
dapperder 'braver'

The structure of these forms is given in (11.68) - (11.70), where, for the present, the epenthetic [d] is not given in the representations for the forms in (11.66) and (11.67):

(11.68) \[ V_a \rightarrow V_b \rightarrow \text{vowel r e} \]
(11.69) \[ V_a \rightarrow V_c \rightarrow V_b \rightarrow \text{vowel vowel r e} \]
In (11.68), the sequence \( V + C + V \) (cf. (11.60d)) corresponds to the canonical configuration established for the diminutives. However, in (11.69) and (11.70), we see the sequence \( V + V + C + V \) - in (11.69) by virtue of the stressed vowel being long, and in (11.70) by virtue of the fact that it is bisyllabic (cf. (11.60a) and (11.60c)). However, the effect of adding the final \( V \) (i.e. the vowel of the comparative suffix) is to create a situation in which three \( V \) nodes are dependent on the \( V \). This, presumably, is an overloaded configuration in terms of the number of dependent \( V \)'s. [d]-epenthesis creates the following structure for the forms in (11.66) and (11.67):

\[
\begin{align*}
(11.70) & \quad V_a \\
& \quad \downarrow \\
& \quad V_b \\
& \quad \downarrow S \\
& \quad V_c \\
& \quad \downarrow V_d \\
& \quad S \\
& \quad V, C
\end{align*}
\]

vowel vowel r e

vowel vowel r d e
in which, although there are still three $|V|$s dependent on $|V_a|$, the effect of the intervening $|C|$ is to break up the offending structure – the addition of $|C|$, then, reduces the $|V|$-ness of the whole configuration, and, in the sequence preceding $|C|$, we again find the canonical configuration established for the diminutives.

The adoption of a phonological model which expresses structural relationships in this way has enabled us to show the regularities and motivations behind the choice of the diminutive suffix in words ending in a sonorant consonant, as well as throwing light on other aspects of the phonological system of Modern Dutch. In particular, we have shown that H & K's assertion below can only be true in a model which fails to take an adequate view of phonological structure:

De invoeging van schwa voor /tje/ bij woorden die uitgaan op een nasaal of een liquida is niet regelmatig.

[The insertion of schwa before /tje/ in words ending in a nasal or a liquid is irregular.]

(Haverkamp-Lubbers and Koolj 1971:5)
References

Abbreviations:

ARIPUC - Annual Report of the Institute of Phonetics, University of Copenhagen
CLS - Papers from the Annual Regional Meeting, Chicago Linguistic Society
EWPL - Edinburgh Working Papers in Linguistics
FL - Foundations of Language
FLH - Folia Linguistica Historica
IJAL - International Journal of American Linguistics
JAOS - Journal of the American Oriental Society
JASA - Journal of the Acoustical Society of America
JIPA - Journal of the International Phonetic Association
JL - Journal of Linguistics
JPh - Journal of Phonetics
Lg - Language
LI - Linguistic Inquiry
SAL - Studies in African Linguistics
SL - Studia Linguistica
YPL - York Papers in Linguistics
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