10 Feature Systems

Much of this book refers to features, understood as components of speech. This chapter reviews and explores the concept of features. After a general introduction (10.1), various kinds of feature – or ways of conceptualizing features – are explained:

- acoustic features (10.2)
- articulatory features (10.3)
- perceptual features (10.4)
- distinctive features (10.5)
- cover features (10.6)
- abstract features (10.7).

The issue of the accuracy and universality of such features is then taken up in 10.8 and 10.9.

The latter part of the chapter emphasizes the discreteness of features (10.10) and then moves on to two related issues that have been prominent in recent phonological discussion:

- the hierarchical organization of features (10.11)
- the notion of feature geometry (10.12).

An overview concludes the chapter (10.13).

10.1 Introduction

Features or components have long been implicit in the description of speech. Even descriptions which focus on segmental sounds frequently recognize characteristic features of these sounds: for example, the description of [p], [t] and [k] as voiceless plosives implies shared features of 'voicelessness' and 'plosiveness', contrasting with other sounds which are not voiceless or plosive. Indeed, most

of the earlier chapters of this book have assumed phonetic components of this kind, such as voicing and nasality, and in chapter 5 in particular we made explicit use of features in phonological rules, in keeping with the tenets of generative phonology.

Explicit attention to features has been driven by a number of motives. In the earliest records of speech description, from ancient India, sounds are labelled and classified by various criteria. The term *dantya*, for example, was used by the Sanskrit grammarians in much the same way as modern phoneticians use its English equivalent 'dental', to refer to the point of articulation of certain consonants. Many of the terms used in Sanskrit grammar have a similarly direct reference to articulation (and have influenced the terminology of modern phonetics) but others may have been motivated more by systemic considerations than by articulatory accuracy. The Sanskrit sound usually transcribed as *v*, for example, may well have been pronounced as a labio-dental fricative, yet the grammarians' description of it was as a 'labial semivowel', suggesting [w] rather than [v] (Whitney 1889). The reason for this is that there are regular alternations between semivowels and vowels in Sanskrit, such that, for instance, a word-final *u* will be rewritten as *v* (i.e. [w]) if followed by a dissimilar vowel (e.g. *madhu iva*, written as *madhv iva*; cf. section 3.13 above). Moreover, the Sanskrit classification of sounds such as [w] and [j] as 'intermediate' may be due simply to their position in the sequential tabulation of sounds and not intended to indicate their 'semivocalic' nature (Whitney 1889, section 51). Thus features are not uncontroversial labels for objective characteristics of speech but may be used in various ways to indicate the nature, status and function of sounds within a linguistic system.

10.2 Acoustic features

A speech sound wave (or some visual display of it, such as a spectrogram) can be analysed in terms of its acoustic properties. Acoustic phoneticians normally describe these properties in terms of measurable scales or parameters, such as intensity or frequency of spectral components (e.g. Fant 1973, p. 26). It should be noted, however, that some characteristics lend themselves fairly readily to simple two-way choices (e.g. presence or absence of fundamental frequency) and that overall pattern (e.g. distribution of formants) may be at least as significant as more easily quantified measures (chapter 7 above).

Partly for this reason, acoustic features are rarely systematized fully independently of articulation and perception. Presence of a fundamental component (F_0) is, for example, readily related to the articulatory feature of voicing, and formant patterns may be similarly related to perceived vowel qualities (section 7.15 above). Some analysts have nevertheless tried to take account of acoustic properties in drawing up sets of features (as in the classic concept of distinctive features; section 10.5 below).

10.3 Articulatory features

Articulatory terminology is in fact far more common than acoustic, largely because observation of the movements and positions of articulatory organs is less crucially dependent than acoustic analysis on instrumentation, and because there is a long tradition of regarding articulation as the ultimate substance of speech.

Articulatory features are again often regarded as physical scales, but the terminology is reasonably varied. The fairly rough and ready traditional terms, such as the dimension of consonant place, with values bilabial, labio-dental, dental, etc., have been refined both by improved accuracy of measurement of physiological phenomena and by general revision of perspective (for instance, by describing palatal and velar consonants in terms of tongue configuration rather than point of articulation).

Feature systems that use articulatory terms include Ladefoged's 'linguistic phonetic features' (2006, p. 268) and Chomsky and Halle's 'phonetic features' (which are said to be articulatory correlates of more abstract features; 1968, pp. 293ff.). In fact neither system is strictly articulatory: Ladefoged uses cover terms such as 'coronal' and 'radical' that relate rather indirectly to articulatory events (2006, p. 269), while Chomsky and Halle introduce (by footnote) a feature of 'syllabicity' which is almost certainly intended to be perceptual rather than articulatory (1968, pp. 302, 353–4).

Generative phonologists continued to pay some attention to the articulatory basis of features during the 1980s. Halle (1983) suggested that features should be taken to be neural commands which activated certain articulators with specific muscular gestures. This continuing interest in articulation also took note of the way in which features need to be related to each other. It is clear that some articulatory movements, such as laryngeal setting and lip rounding, are relatively independent of each other. On the other hand, features specifying tongue position, such as 'high', 'back' and 'low' – originally listed in Chomsky and Halle's scheme as if they were independent variables – are related by the fact that they are all gestures or settings of the dorsum of the tongue.

To represent the relationships among these articulatory features, generative phonologists have developed a 'feature tree' (figure 10.3.1). Figure 10.3.1 shows both how features are related to articulators (such as tongue root and soft palate) and how they are hierarchically ordered (such that, for example, the selection of values for [high], [low] and [back] is possible only for dorsal sounds and not for labials or coronals). The model is explained in Halle (1992) and a detailed account can also be found in Kenstowicz (1994, esp. chs 4.3 and 9.1). We will return to some of the implications of the model in sections 10.11 and 10.12 below.

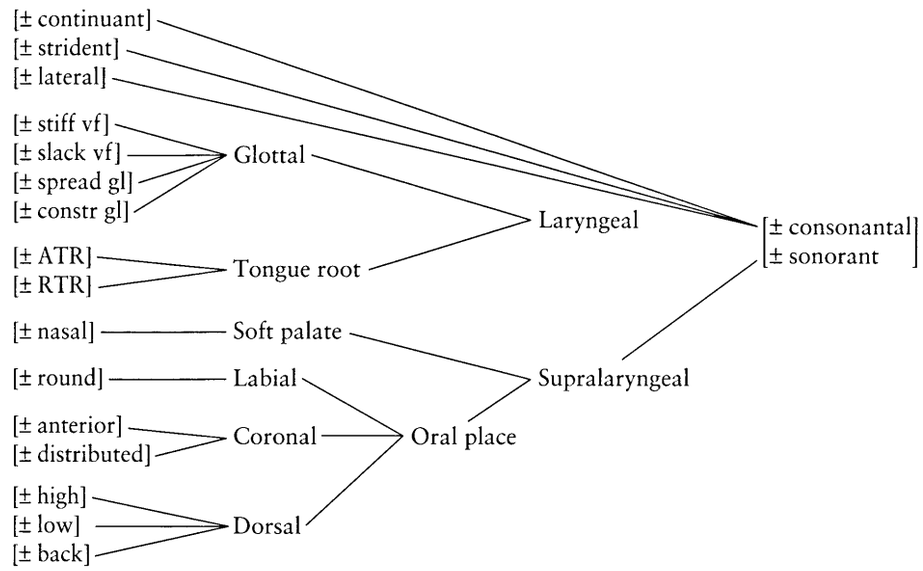

Figure 10.3.1 Articulatory feature tree
Source: Kenstowicz 1994, p. 452; based on Halle 1992.

10.4 Perceptual features

It would be possible to characterize speech in terms of its auditory qualities, and it is noteworthy that most languages do have terms to describe perceived qualities of speech sounds. Some of these terms may be auditory descriptives used also of nonspeech sounds, such as 'hiss' or 'buzz'; others represent synesthetic impressions, such as 'dull', 'heavy' or 'sharp'. Australian Aborigines, for instance, seem to describe the postalveolar 'retroflex' consonants of their languages as 'heavy', as opposed to 'light' alveolar consonants. In common usage, terms like these are not likely to be employed for systematic description or analysis. There are some striking, if individual, examples, such as Rimbaud's sonnet in which the vowels A, E, I, O, U 'correspond' to the colours black, white, red, green and blue, and there is of course a substantial tradition of discourse within literary studies about the esthetics of sounds, including onomatopoeic effects (see e.g. Ullmann 1970, pp. 82–91, 129–30). Phoneticians and linguists have done little with these impressionistic terms other than adopt some of them for their own purposes.

Of relevance here is the fact that human beings do not normally perceive speech for the purpose of identifying overt qualities analogous to textures or colours. Speech perception is focused on differences or distinctions, not as ends in themselves, but in order to discriminate utterances. Hence perceptual features are usually treated systematically as 'distinctive features' rather than as auditory properties.

10.5 Distinctive features

It has long been recognized that any language has a limited number of phonological contrasts or oppositions. For example, Jakobson (1939, 1949), drawing on earlier phonological concepts of de Saussure and Hjelmslev, pointed to the limited number of 'differential qualities' or 'distinctive features' that appeared to be available to languages. Given that no two languages are phonologically identical, distinctive features must be, to some extent at least, language-specific. Nevertheless Jakobson's interest was in showing how oppositions – as the constitutive features of relations among phonemes – reflected a hearer's response to an acoustic signal. Just as this signal contains a limited number of variables, so perceptual response to it operates with a limited number of categories.

The most famous elaboration of this approach is expounded in works by Jakobson et al. (1952) and Jakobson and Halle (1956). This scheme uses perceptual terms which reflect acoustic cues rather than articulatory mechanics. Thus in 1939, Jakobson had already taken up Grammont's terms 'acute' and 'grave', representing opposite ends of a scale that measures the predominance of upper or lower components of the acoustic spectrum. The 'acute–grave' feature distinguishes both high front vowels from back vowels and palatal consonants from velar consonants. Inasmuch as both high front vowels and palatal consonants show greater high-frequency predominance, they may be termed 'acute' in opposition to back vowels and velar consonants, which are relatively 'grave'.

Jakobson and Halle employed only 12 features, which were listed with articulatory ('genetic' or 'motor') correlates as well as acoustic cues (1956, pp. 29ff.). The features are listed in table 10.5.1, and given in more detail in appendix 2.1. All of the features are polar oppositions, allowing relative values. Hence the acute vowels of one language need not be identical in nature with the acute vowels of another, provided that they are more acute than the grave vowels to which they are opposed. Moreover the same acoustic effect (and perceptual impression) can be achieved by different articulatory means. Lip rounding, pharyngealization and retroflexion, for instance, may all be covered by the one distinctive feature of 'flatness'. Hence the 12 features allow for considerable articulatory diversity. Each feature is nevertheless binary, with only two opposed values along a single dimension, although a third 'unmarked' value is sometimes implied. Thus in a language like Russian, with distinctive palatalization of consonants, some consonants are 'sharp', others 'plain'; in a language like English, where there is no such distinction, consonants may be considered redundantly 'plain', but on one interpretation of distinctive feature theory, this amounts to saying that consonants are neither 'sharp' nor 'plain'. Tables of feature values sometimes enshrine this interpretation by leaving some features blank or marking them as zero. Table 10.5.2 gives a selection of English consonants marked for their distinctive feature values, including 0 where the feature may be judged redundant or irrelevant.

Table 10.5.1 Distinctive features (each feature is listed as a pair of opposed terms, which are to be interpreted relative to each other)

1	Vocalic/nonvocalic	Distinguishes vowels and vowel-like sounds from nonvocalic sounds like stops and fricatives
2	Consonantal/ nonconsonantal	Distinguishes sounds with low energy and relatively substantial obstruction in the vocal tract from nonconsonantal sounds; thus, for example, a typical vowel can be considered vocalic and nonconsonantal, a plosive nonvocalic and consonantal, an approximant such as a lateral both vocalic and consonantal, and a glottal stop nonvocalic and nonconsonantal
3	Compact/diffuse	Refers to the acoustic spectrum and distinguishes sounds with energy concentrated in the central region of the spectrum (such as low vowels and velar consonants) from those with a more 'diffuse' spread of energy (such as high vowels and labial and alveolar consonants)
4	Tense/lax	
5	Voiced/voiceless	
6	Nasal/oral	
7	Discontinuous/ continuant	
8	Strident/mellow	Distinguishes 'noisy' sounds like sibilant [s] from more 'mellow' fricatives like [θ]
9	Checked/unchecked	Refers to the higher rate of energy discharge in glottalized sounds and therefore distinguishes ejectives from pulmonic sounds
10	Grave/acute	Refers to the acoustic spectrum and distinguishes sounds with more energy in the lower frequency ranges (such as back vowels and labial and velar consonants) from those with greater concentration of energy in the upper frequencies (front vowels and alveolar consonants)
11	Flat/plain	Refers to the lowering or weakening of upper frequencies created by some kind of narrowed aperture: distinguishes lip-rounded sounds from nonrounded, as well as other articulations with comparable acoustic consequences, notably pharyngealized consonants from their 'plain' counterparts
12	Sharp/plain	More or less the opposite of 'flat/plain' and refers to the upward shift of upper frequencies characteristic of palatalized consonants

Source: Jakobson and Halle 1956; see appendix 2.1 for further details.

10.6 Cover features

The Jakobsonian concept of distinctive features revives a prospect already entertained in Sanskrit phonetics (section 10.1 above), and certainly perpetuated by

Table 10.5.2 Distinctive feature values of some English consonants

	p	*t*	*k*	*b*	*d*	*g*	*f*	*s*	*v*	*z*	*h*	*m*	*n*	*ŋ*
Vocalic	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Consonantal	+	+	+	+	+	+	+	+	+	+	−	+	+	+
Compact	−	−	+	−	−	+	−	−	−	−	0	−	−	+
Tense	+	+	+	−	−	−	−	−	−	−	0	−	−	−
Voiced	−	−	−	+	+	+	−	−	+	+	−	+	+	+
Nasal	−	−	−	−	−	−	−	−	−	−	−	+	+	+
Discontinuous	+	+	+	+	+	+	−	−	−	−	−	−	−	−
Strident	−	−	−	−	−	−	+	+	+	+	−	−	−	−
Checked	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grave	+	−	+	+	−	+	+	−	+	−	0	+	−	+
Flat	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sharp	0	0	0	0	0	0	0	0	0	0	0	0	0	0

twentieth-century linguists such as Sapir (1925), namely that, within a particular linguistic system, sounds may be classified by criteria that transcend acoustic or articulatory properties.

In describing a language, it is often convenient to refer to classes of sounds that are not well defined by features. In English, for example, the consonants / l r w j / have some functional characteristics in common – they are the only English consonants that can form clusters with preceding voiceless plosives (as in *click*, *crick*, *quick*; *clue*, *crew*, *cue*, etc.), and they show a common tendency to devoicing in this environment. Nevertheless there is no acoustic, articulatory or perceptual feature specification that neatly unites them, other than the negatively phrased 'nonobstruent non-nasal consonants'. There is no single feature available of the kind that specifies all voiced sounds or all nasal consonants.

Now the extent to which classes of sounds are neatly described by one or two feature values will obviously depend on the particular feature system being used. Chomsky and Halle include in their scheme a feature 'anterior', which refers to sounds articulated in front of the palato-alveolar region. This feature would (if necessary) allow easy characterization of a class of consonants including [p] [t] [b] [d] [f] [s] [v] [z] but excluding [k] [g] [x]. In Ladefoged's scheme, which does not employ 'anterior', the specification would not be as straightforward. The question is, of course, whether 'anterior' sounds do constitute a class that needs to be identified in this way.

In fact the term 'cover feature' has a critical overtone and was originally intended to refer to precisely those features which had no measurable phonetic correlate but which 'covered' a class of sounds (Sommerstein 1977, pp. 96, 111). In its narrowest sense 'cover features' can be taken to mean only features which provide convenient labels for combinations of other features. For example, the term 'sonorant' may provide a label for the class of sounds that are neither stops nor fricatives – the label is convenient and applies to a specifiable class even though its precise phonetic meaning is controversial. Many traditional categories are in fact of this kind: the class of consonants in many languages includes syllabic consonants and vowel-like approximants which may not be readily identifiable as consonants on acoustic or articulatory grounds; or the term 'vowel' may cover not only vocalic sounds but also syllabic consonants (section 3.14 above). In a wider sense, 'cover feature' may apply to any feature required in the description of a language, including *ad hoc* features which have little or no phonetic basis at all. We will deal with the latter as 'abstract features'.

10.7 Abstract features

Sapir's contention (1925, p. 19) that there are criteria by which one can determine the 'place' of a sound in a system 'over and above its natural classification on organic or acoustic grounds' argues for a certain abstraction in phonological description. The suggestion is that the sounds of language need not be characterized in the apparently 'concrete' terms of acoustics and articulation.

Total divorce of phonological features from a phonetic basis is in fact rarely if ever entertained. We could, in theory, describe the three vowels of many Australian Aboriginal languages with three *ad hoc* features: /i/ is 'sharp', /a/ 'dry' and /u/ 'soft'. It is hard to imagine any reason for an abstraction of this kind, and the features would in any case have to be mapped on to genuine features to make phonetic sense – for example, 'soft' means perceptually 'grave', or articulatorily 'back and lip-rounded', and so on.

There may nevertheless be linguistic justification for abstraction of the kind that is responsive to systemic criteria, such as patterns of distribution and assimilation. Suppose, for example, that the nouns of a language end in /p/ /t/ /m/ or /n/ and that their plurals are signalled by these changes in the final consonant: p → f, t → s, m → b, n → d. Here we might justify treating /p t m n/ and /f s b d/ as two parallel classes of sounds, even labelling them, say, 'hard' and 'soft', so that /p/ and /f/ are hard and soft counterparts, and so on. We might expect that speakers of the language would find this classification quite reasonable, given their sense of how sounds function in the language, despite the fact that 'hard' and 'soft' do not directly correspond to straightforward phonetic qualities.

Sapir himself explicitly defended the notion that sounds could be 'felt' by native speakers to be other than what they were phonetically. Arguing in terms of segments rather than features, he maintained, for example, that English speakers feel [ŋ] to be a sequence of two consonants, [ŋg]. This apparent defiance of articulatory reality is justified not by the spelling *ng* but by the restricted distribution of English [ŋ], which, for instance, does not appear in syllable-initial position, as the true nasal consonants [m] and [n] do (see Sapir 1925 for this and other examples).

In fact the traditional grammars of many languages enshrine classifications of this kind, often applied, by way of spelling rules, to letters rather than sounds. In Arabic, for example, 14 of the letters are classified as 'sun' letters

by the criterion of assimilation of the preceding definite article. (The definite article *al-* becomes *as-* before *s*, *an-* before *n*, etc., and /ʃams/ 'sun' begins with one of the 14 letters that trigger such assimilation.) The term 'sun' is clearly nonphonetic but is almost equivalent to 'dental/alveolar', 'apical' or 'coronal'. Note, however, that [d] and [ʒ] *are* 'sun' consonants, while the affricate [dʒ] is not. Historically, this affricate is derived from [g], and a generative treatment of Arabic might regard it as underlyingly velar; but in terms of current pronunciation (in most dialects of Arabic) the class of consonants that triggers assimilation is not neatly specifiable.

Other examples of traditional classifications include the Slavonic terms 'soft' and 'hard' and the Celtic (Irish) 'slender' and 'broad', correlating (more or less) with palatalized (or palatal) and nonpalatalized consonants. And the history of English spelling is such that ten of the English vowels are often presented as five 'long' and five 'short' paired values of the letters A E I O U, even though the opposition within each pair (e.g. long A [eɪ] versus short A [æ]) is certainly not merely one of duration.

10.8 Accuracy and universality

Descriptive accuracy requires that we recognize the principled distinction among different kinds of features. This point has been emphasized by Fudge (1967; 1973b, esp. p. 174), particularly with respect to acoustic, articulatory and perceptual (auditory) features, each of which represents a different perspective on speech.

Nevertheless, some phonologists, especially in the generative tradition, are opposed to this differentiation. In their view, features should not be of different kinds at different levels. Thus the features of Chomsky and Halle's system serve both as a universal descriptive inventory and as the elements of a language-specific classification. The feature 'tense', for example, is supposedly a universal label referring to acoustic and articulatory properties, but is also the means of identifying a functional class of tense vowels within the phonology of English. An important principle of this tradition of feature analysis is the concept of NATURAL CLASS: it is expected that the classes of sounds that are relevant in the description of particular languages will be natural, in the sense that they have a clear phonetic foundation.

Examples of natural classes in English include the following. An English syllable can begin with various combinations of /s/ and some other consonant:

sp	e.g.	spy, spear, spoon
st		sty, steer, stool
sk		sky, scare, school
sf		sphere, sphinx
sθ		sthenia, sthenic
sm		smile, smear
sn		sneer, snare
	etc.	

But a group of sounds is systematically excluded from following /s/ at the beginning of a syllable, namely voiced stops and fricatives. There are no words beginning /sb/, /sd/, /sg/, /sv/ etc. We call this a systematic restriction because speakers of English are likely to consider the excluded sequences unpronounceable, or at least foreign to normal English patterns of speech. It is a different matter with sequences such as /sf/ and /sθ/ – these are admittedly rather rare but they are admissible in a way that /sb/ and /sv/ are not. The excluded consonants are of course a natural class, given that they can be defined as voiced obstruents.

A second example from English concerns the vowels that can occur in open monosyllables: *paw*, *bee*, *may*, *toe* and so on. One class of vowels cannot occur in this position, and this again proves to be a natural class, namely short (or 'lax') vowels. The number and quality of these vowels varies regionally, but in Received Pronunciation (RP) we have six such vowels, illustrated below in closed monosyllables. Note that there are no corresponding open monosyllables containing these vowels, e.g. no /bɪ/ alongside /bɪt/ and /bɪn/:

bit, bin, lick	ɪ
bet, pen, peck	ɛ
bat, ban, lack	æ
foot, book, look	ʊ
but, bun, luck	ʌ
pot, lot, lock	ɒ

A third example from English is that of the consonants that require a vowel in the plural suffix. For most nouns, the plural suffix is /s/ or /z/ depending on the voicing of the preceding segment: *bits*, *locks*, *cliffs* and *moths* all have /s/ following a voiceless consonant, *bids*, *logs*, *buns* and *seas* all have /z/ following a voiced sound. But after a sibilant fricative or affricate, the plural suffix is /əz/ or /ɪz/, as in

masses, losses
buzzes, mazes
rashes, dishes
riches, ditches
ridges, judges.

It is in fact not just the plural suffix that is affected but any suffix of the same shape: the same pattern is observable with the possessive suffix (*Trish's book*, *the judge's opinion*) and with affixation of the verb in the third person singular (*she judges*, *he washes*). The relevant consonants are again a natural class (sibilants).

Largely because of this commitment to natural classes, many phonologists do not distinguish among features, especially at the 'higher levels' of perceptual, distinctive and linguistic (systemic) features. It nevertheless seems necessary to draw a line between perceptually distinctive features of the kind that represent the hearer's categorical discrimination, and linguistic features that characterize classes of sounds defined within a linguistic system. For English speakers, for

example, there is a difference between the perceptual separation of the vowels themselves (as reflected in a speaker's ability to distinguish rhymes) and the potential classification of vowels into categories such as 'tense' and 'lax' (as reflected in the speaker's awareness of distributional or grammatical criteria that identify particular sets of vowels).

Moreover, much of the terminology of features slides between different criteria of description, not always in a way that clearly and explicitly represents any particular theoretical commitment. The term 'voiced' or 'voicing', for example, is probably no longer regarded as specifically acoustic or perceptual and may be applied to (1) the characteristic component of the acoustic signal (the 'voice bar'), (2) the periodic vibration of the vocal cords ('voicing'), and (3) the perceived 'buzz' of relevant sounds ('voiced' sounds). (See for example Jakobson et al.'s description of voicing: 1952, p. 26.) In many cases, a certain looseness does no great harm: 'click' is presumably a perceptual term in origin but is now readily used in the context of describing the suction mechanism (Chomsky and Halle 1968, p. 322; Ladefoged 2006, pp. 139–40). On the other hand, some features are controversial: vowel height often purports to refer to the position of the highest point of the tongue but in fact refers more appropriately to auditory quality and acoustic properties. (Hence Ladefoged's insistence on 'vowel height' rather than 'tongue height', 2006, pp. 87, 189; cf. sections 2.7 and 7.15 above.) And, while generative phonologists may make a principle of using a single set of features for all levels of description, the terminology does often point to one criterion rather than another. In the Chomsky and Halle scheme, feature labels like 'anterior' and 'coronal' are evidently based on articulatory reality; but those like 'strident' and 'sonorant', in name at least, suggest an acoustic or perceptual foundation.

To some extent, this apparent slippage between categories of description indicates that different aspects of speech are integrated. However important it is analytically to distinguish acoustics, articulation, perception and so on, these different levels of reality are integrated under linguistic control. Thus while an acoustic signal must be analysed in its own terms (intensity, frequency, etc.), the criteria by which features and parameters are selected and assigned values must refer to linguistic activity. In short, acoustic features are treated as correlates or realizations of other features. The values of formants within an acoustic spectrum are measured not because they are objective properties of acoustic reality but because they are believed to reflect articulatory settings and to serve as cues in human perception. A similar point can be made about articulatory features. If phoneticians set up a parameter of lip rounding, it is precisely in order to measure the physiological correlate of an acoustic property or of a linguistic feature of certain speech sounds. If phoneticians do not measure the extent to which the nose is wrinkled or the eyebrows are raised during speech, it is because these gestures are judged irrelevant to phonological distinctions (although they may be meaningful *non*speech gestures).

Notwithstanding this integration, some phonologists are rather too glib about the concept of natural classes. It is obviously true that the classes of sounds that are functional in language often have a basis in the nature of articulation or perception. It is entirely to be expected, for example, that the class of sounds

that conditions a particular assimilatory process will have some property or properties that explain the assimilation. There are nevertheless reasons to remain cautious about natural classes. In the first place, there is enough evidence about the variability of articulation and perception to raise doubts about simple equations between phonological classes and their phonetic correlates. We have already noted the example of English 'voiced' stops and fricatives that may be signalled by the length of a preceding segment rather than by voicing. In other words, the difference between *send* and *sent* or between *feed* and *feet* may be, in terms of articulation and perception, more a matter of the length of the preceding segment [n] or [i:] than of the voicing of the stop itself. Now if there is still justification for talking about the voiced stops and fricatives of English as a class of sounds – as presumably there is – the relationship between this natural class and its characteristic property of voicing is, to say the least, indirect. Similarly, the 'back rounded' vowels of a language may not always be back and rounded; and so on.

Secondly, the classes of sounds that prove relevant in linguistic description are sometimes phonetically irregular because of historical changes. An example already mentioned is that of Arabic, where [g] has become [dʒ] by a process of sound change, but has not thereby entered the class of sounds that condition assimilation of the definite article. It would appear that [dʒ] ought to occasion assimilation, since a phonetically comparable sound like [ʒ] does so; but it does not. A second example of this kind can be taken from those varieties of English in which postvocalic *r* is no longer pronounced, unless linked to a following vowel. For most speakers from south-eastern England, Australia or New Zealand, the long vowels and diphthongs fall into three classes, depending on how they are linked to a following vowel. Vowels such as long /i/ and diphthongal /aɪ/ have a linking /j/, as in

me-y-and my-y-uncle

while long /u/ and diphthongal /aʊ/, for instance, have linking /w/, as in

you-w-are now-w-over Kangaroo-w-Island.

But a third group of vowels take linking /r/. These vowels are

/a/ as in spa; a spa-r-in Germany
/ɔ/ as in law; law-r-and order
/ɜ/ as in her; her-older brother
/ə/ as in Cuba; Cuba-r-is an island.

Diphthongs ending in /ə/ (as in *hear* and *hair*) behave in the same way. Now the vowels that take linking /j/ can be considered front vowels (including diphthongs that move towards a front vowel) and those that take linking /w/ are back rounded vowels (or diphthongs that move towards a back rounded vowel). But the group that takes linking /r/ is by no means an obvious natural class: it includes back rounded /ɔ/ as well as central vowels, and may also include

front vowels, for many Australians and New Zealanders pronounce the vowels of *hear* and *hair* as long front vowels with little or no centring offglide. That this group of vowels continues to take linking /r/, despite its articulatory and auditory diversity, argues that patterns may be set up in language that do indeed, as Sapir would have it, transcend natural classification. The point should not be exaggerated – much of phonological organization is natural in the sense under discussion – but it is at least evident that a sound change does not always lead to reorganization in accordance with what linguists take to be natural principles.

10.9 Universal feature systems

The classic feature systems, such as Jakobson and Halle's (1956) and Chomsky and Halle's (1968), have put considerable emphasis on universal validity. Chomsky and Halle say of their feature system: 'The total set of features is identical with the set of phonetic properties that can in principle be controlled in speech; they represent the phonetic capabilities of man and, we would assume, are therefore the same for all languages' (1968, pp. 294–5). In the light of the preceding section it should be noted that this approach to universal properties assumes that they are under (linguistic) control and that it is indeed possible to correlate features of different levels.

Chomsky and Halle relate 'physical' properties to potentially language-specific features by distinguishing description from classification. A single feature value, say [+round], may be used to *classify* the vowels of a language, i.e. to specify those vowels which are distinctively or functionally rounded. In this role, the feature may be considered an abstract or functional property of the phonological system. In assessing the acoustic or articulatory correlates of this property we may use the feature as a *descriptive* parameter: it is then possible to measure the range of articulatory lip rounding (and its acoustic correlate) which will count as [+round] for this language. Notice that this approach allows for features to be binary within the system (vowels are either [+round] or [–round]) but to be multivalued scales in their articulatory or acoustic realization (lip position may vary from fully spread to fully rounded, and the feature might have values from [0round] to, say, [5round]).

It remains controversial, however, whether a linguistic feature value is necessarily realized by a single articulatory or acoustic scale. Suppose, for example, that [+round] vowels were actually signalled, in articulation, by a rather complex interaction of tension, compression and protrusion of the lips. Nor is it clear whether feature labels must be appropriate across all correlates – for example, whether there is any principled objection to the possibility that phonological *lip rounding* correlates with articulatory *lip protrusion*, perceptual *graveness* and acoustic *flattening* (of certain formants). (The point here is of course not to assert the truth of this correlation but to question whether the possibility should be ruled out in principle.)

In general, phonologists seem to be motivated not only by economy of description – by a reluctance to multiply terms for different aspects of a feature – but also by caution about abstract features. Principles of 'naturalness' have been taken to mean that phonological features must have genuine phonetic meaning (sections 5.8 and 5.9 above). The effect of this constraint is that in cases such as the Sanskrit [v] (functionally a [w]), or English [ŋ] (functionally [ŋg] according to Sapir and others), there is no possibility of inventing entirely *ad hoc* features, such as 'semifricative' to classify a [w] which is actually articulated as a [v]. The result of this strategy is that the burden of explaining the discrepancy between levels of reality falls on rules that derive one feature specification from another, rather than on the feature system itself. The trend, at least in classic generative phonology, has been to favour rule complexity within a unified feature system; and *The sound pattern of English* (SPE) (Chomsky and Halle 1968) not only embraces Sapir's proposal that [ŋ] be specified as a cluster of nasal consonant plus [g] (p. 171 n.), but, for example, also takes [ɔɪ] to be a front rounded vowel, which is of course converted into a diphthong by phonological rules (pp. 191–2). More recently, attention has turned away from rule complexity to the representation of features – and particularly to richer concepts of structural organization (sections 10.10 and 10.11 below). (For further discussion of classic approaches to features, see Chomsky and Halle 1968, pp. 293–9; Sommerstein 1977, esp. pp. 92–7, 108–13.)

10.10 Features and discreteness

Differences among languages are such that if there are universals of human speech they are found not in a universal inventory of phonetic properties but in the universal nature of sound waves and articulatory organs, and in the universality of systematic discreteness. Since sound waves and articulatory movements are continua, it is human response to them which brings the discreteness of a linguistic system.

This discreteness is both paradigmatic and syntagmatic. Paradigmatically, the continua of acoustics and articulation are converted, via perceptual choices, into a finite set of sounds. As Jakobson puts it: 'Where nature presents nothing but an indefinite number of contingent varieties, the intervention of culture extracts pairs of opposite terms' (1949, p. 321). Syntagmatically, this discreteness entails linear segmentation of speech. Extending Jakobson's point, Halle notes that humans are capable of listening to speech ('a continuous flow of sound, an unbroken chain of movements') and recording it as a sequence of discrete written letters (1954, esp. pp. 333, 337–8).

It is not necessarily a consequence of this discreteness that features are perfectly in phase with each other. We may represent the English word *pan* as a sequence of three sets of features, for example, as in figure 10.10.1. We know nevertheless that the onset of voicing after an English voiceless stop will be somewhat delayed, creating the effect of aspiration, that the coupling of the

p	æ	n
−voice	+voice	+voice
+labial	−labial	−labial
+stop	−stop	−stop
−nasal	−nasal	+nasal
−high	−high	−high
−back	−back	−back

Figure 10.10.1 Example of a feature matrix: English *pan*

nasal cavity for [n] may substantially precede the consonant, even to the point where the vowel is fully nasalized by anticipatory assimilation, and so on. Indeed given the continuous nature of articulation, it would be surprising if all articulatory gestures and acoustic cues could be assumed to be contained within segmental boundaries (section 3.1 above).

This point has been emphasized in some approaches to phonology. Firth made it a virtue of 'prosodic phonology', in which prosodies included features that extended over more than one segment, for example nasality extending over vowels adjacent to nasal consonants (Robins 1957; Palmer 1970; Sommerstein 1977, ch. 3; and section 11.8 below). More recently, autosegmental phonology has paid particular attention to phenomena such as vowel harmony (in which all vowels within a word may have to agree in respect of features such as 'back' and 'round') and suprasegmental assignment of tone (in which tonal distinctions may be mapped on to one or more segments, depending on the structure available). CV phonology has similarly addressed questions of the linear organization of speech. Both autosegmental and CV phonology or more generally nonlinear phonology envisage a structured representation of speech such that features are not automatically contained within segmental units but are mapped, in various ways, on to a segmental 'skeleton' (Goldsmith 1979, 1989; section 11.12 below).

These approaches question the traditional status of the segment – and revive a constant worry in phonology: that our interest in segmental transcription and representation is driven more by tacit emulation of alphabetic writing systems than by genuine insight into the nature of phonological organization. In this light, features or components may indeed be a more realistic model of the smallest or most fundamental units of speech. But the contention does not undermine discreteness as such. In short, although there is room for debate about the formal representation of linear organization, there is little dispute about the fundamental principle that the units of language are discrete, despite the continuousness of speech.

10.11 Hierarchical organization of features

Classic feature systems – such as the distinctive features of Jakobson et al., or Chomsky and Halle's system – assume that a segment is realized as, or can be rewritten as, a set of features, but they recognize no internal grouping of the features within a segment. In this respect figure 10.10.1 above is representative of most approaches, in that each segment is represented as an array of features, with no significance attaching to the order in which the features are listed down the array, and no explicit grouping of the features as 'point of articulation features' or 'vowel quality features'.

Features have nevertheless often been implicitly categorized in some way or other. Schane's summary of features, for example, which to some extent follows Chomsky and Halle, presents features under headings 'major class features', 'manner features', 'place of articulation features', 'body of tongue features' and 'subsidiary features' (Schane 1973, ch. 3). These headings scarcely provide consistent categories ('body of tongue features' actually includes lip rounding, for instance) and, more importantly, they are not intended to play any part in formal description. From the 1980s, however, there has been renewed interest in categorizing features in ways that show their interrelatedness or interdependency. We have already mentioned the generative phonologists' interest in 'feature trees' (section 10.3 above). In this section we will deal with a rather different approach to dependency developed by Anderson and Ewen (1987) and known simply as 'dependency phonology' (see also section 11.15 below). In the next section (10.12) we will return to the generative interest in what is now being called 'feature geometry'.

Dependency phonology draws on classic thinking about features – it assumes, for example, that features should be natural, that they should make sense phonetically. But it allows far more diversity among the features themselves than most approaches. In dependency phonology, some features are scalar, allowing several values along a continuum; others are binary. Moreover, binarity is taken in an older sense to represent a choice between presence and absence of a feature, rather than in the orthodox generative sense of + and −. At the same time, the features are in some ways reminiscent of the classic distinctive features of Jakobson et al.: components such as 'lowness' (or 'sonority') and 'roundness' (or 'gravity'), for example, may be relevant to consonants as well as to vowels. These features may also be relative, in the traditional functional sense: a particular feature value implies an opposition within the relevant language without implying that the opposition is phonetically constant across all languages.

Most of the terms used in dependency phonology are familiar enough, including for instance 'consonantality', 'apicality' and 'nasality'. What is of particular interest is the way in which the concept of dependency contributes to description. Dependency phonology emphasizes the importance of functional subgroupings of features and of the internal organization of features within segments. In Chomsky and Halle's scheme, for example, assimilatory processes – such as assimilation of a nasal consonant to the point of articulation of a following consonant – require reference to all the relevant features, say 'anterior', 'coronal' and 'high'. But if features are grouped, so that all point-of-articulation features form a natural subgroup, it is possible to describe an assimilation simply as agreement of that set of features. It is interesting in this regard that Chomsky and Halle do in fact group their features under headings such as

'major class features' and 'cavity features'; but they make no use of this in describing the structure of the segment itself.

Not only does dependency phonology explicitly group features within the segment, it also recognizes the relative preponderance of various components within the segment. Thus the basic dimensions of vowels (often described as height, backness and lip rounding) are accounted for by three components, namely 'frontness', 'lowness' and 'roundness'. Departing from customary notation, dependency phonology represents these three not as bracketed labels but as the elements |i|, |a| and |u|. But these three may be combined, so that a vowel phoneme such as /e/ may be represented as {|i,a|}, combining frontness and lowness, or /y/ as {|i,u|}, combining frontness and roundness. Moreover, the notation of dependency phonology allows for components to 'preponderate' to a greater or lesser extent. Where a language distinguishes /e/ from /ɛ/, the higher vowel may be represented with frontness preponderant over lowness, the lower with lowness preponderant over frontness. Using arrows to indicate the preponderance, we have {|i⇉a|} for /e/ and {|a⇉i|} for /ɛ/. If it were necessary to make a further distinction, we could distinguish

{|i⇉a|} = /e/
{|i⇄a|} = /ɛ/
{|i⇇a|} = /æ/

Thus although the components are universal, their function may be language-specific. The /e/ phoneme of a language distinguishing only two front vowels /i/ and /e/ is not functionally equivalent to the /e/ of a language which distinguishes four front vowels /i/, /e/, /ɛ/ and /æ/.

Classes of sounds can be specified by the components, but the implications of Anderson and Ewen's bracketing need to be carefully noted (1987, p. 127). {a} refers to any segment containing |a| and therefore includes all nonhigh vowels (i.e. it includes vowels in which |a| is present in any combination), whereas {|a|} refers to a segment containing only |a|. The negation of {a}, namely {~a}, refers to any segment containing a component other than |a|; and {|~a|} refers to a segment containing only a component other than |a|. The other notational conventions of dependency phonology are available as well, so that {a,} refers to segments containing |a| and some other component, {a,~a} refers to segments containing |a| and a component other than |a|; and so on.

With considerable phonetic realism, dependency phonology categorizes features as gestures. The two basic gestures are the CATEGORIAL and the ARTICULATORY. The categorial gesture is divided into the subgestures of PHONATION and INITIATION, which between them include the components corresponding to what traditional phonetics would call the selection of airstream mechanism, the consonant–vowel parameter of periodicity, and phonatory settings. The articulatory gesture is also divided into two subgestures, the LOCATIONAL and the ORO-NASAL. The first of these includes all the components relating to point of articulation and tongue configuration, such as 'frontness', 'lowness', 'linguality', 'dentality' and 'laterality'. The oro-nasal subgesture separates nasal coupling from the other articulatory settings and refers simply to the component of

Table 10.11.1 Components in dependency phonology

Gesture	*Subgesture*	*Components*
Categorial	Phonation	Consonantality (a scale ranging from |C| to |V|)
	Initiatory	|O| degree of glottal opening
		|G| glottalicness
		|K| velaricness
Articulatory	Locational	|i| frontness
		|a| lowness
		|u| roundness
		|ə| centrality
		|l| linguality
		|t| apicality
		|d| dentality
		|r| retracted tongue root
		|λ| laterality
	Oro-nasal	|n| nasality

Source: Anderson and Ewen 1987, chs 4–6; see also appendix 2.4.

nasality. Thus the four subgestures correspond broadly to major articulatory categories recognized in phonetics, although there is certainly room for argument about, for example, the appropriateness of treating tongue posture as part of the locational subgesture or about the exact nature of the distinction between phonation and initiation.

The case in favour of dependency phonology is argued at some length by Anderson and Ewen (1987, esp. part II, 'Phonological gestures and their structure'); and there is some convergence between dependency phonology and other recent work in autosegmental and CV phonology (Anderson et al. 1985). The components of dependency phonology are listed in table 10.11.1 (more detail is given in appendix 2.4).

10.12 Feature geometry

The term 'feature geometry' has become common in discussion of the way in which phonological features are grouped or structured. In his survey of generative discussion of this topic, Kenstowicz draws on the classic Jakobsonian concept of phonological segments as 'bundles of distinctive features' (section 10.5 above), adding that these bundles are 'internally structured' and that the behaviour of segments 'can be understood from the elucidation of this internal feature structure' (1994, p. 451). Kenstowicz comments on the similar interest underlying other work, such as dependency phonology, but also points out that there is a difference between postulating feature structure within segments and

treating some segments as elements within others (as in dependency phonology, where [e] may be analysed as [i] plus [a]; section 10.11 above). As Kenstowicz puts it, this is 'one of the most active and unsettled areas of current phonological theory, with many competing proposals' (1994, p. 451).

We have already seen (section 10.3 and figure 10.3.1 above) that many generative phonologists now model features as a tree, designed to reflect the way in which features are interrelated, starting with the Halle–Sagey model (Halle 1992). Thus, apart from what we might call 'nonlocalized' features such as [consonantal] and [strident], features are grouped as laryngeal or supralaryngeal; laryngeal is further divided into two articulators, namely the glottis (contributing mainly to phonation) and the tongue root (contributing mainly to pharyngealization), and supralaryngeal is divided into the soft palate (as the articulator governing airflow through the nasal cavity) and three 'oral place' articulators, namely labial, coronal and dorsal.

This tree organization carries through, so to speak, to the specification of individual segments, so that the feature representation of [s], for example, might be displayed as in figure 10.12.1, rather than as a simple array of unordered features.

It must be said that this kind of structure remains controversial. For example, it is not self-evident that [lateral] should be treated as a stricture feature, independent of place, rather than as a feature selected only in conjunction with certain articulatory settings; and it is similarly debatable whether [pharyngeal] should be a feature representing an additional category of articulatory place, alongside [labial], [coronal] and [dorsal]. There has been considerable argument in generative phonology about such questions, some of the debate intersecting with discussion of the linear arrangement of features (including the question of how to represent complex segments such as affricates, as well as that of how to model syllabic organization and phenomena such as vowel harmony). This debate is picked up again in chapter 11, especially from section 11.12 on;

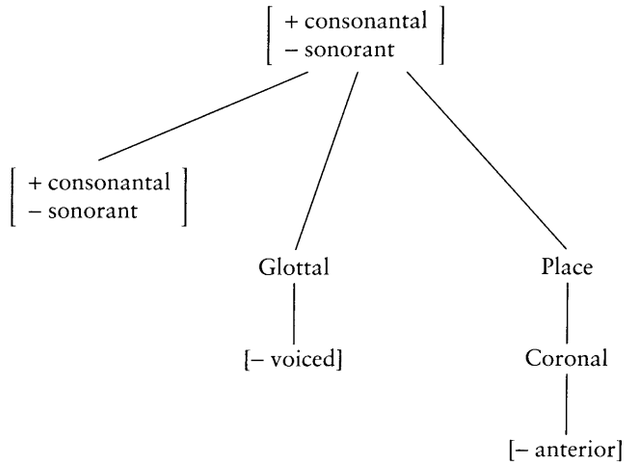

Figure 10.12.1 Tree representation of [s]

for a detailed account of the problems tackled under the heading of feature geometry, see Kenstowicz (1994, ch. 9), and the excellent summary in Clements and Hume (1995).

10.13 Overview

Within phonetics and speech research, acoustic and articulatory features are frequently dealt with as scales, parameters or articulatory gestures. Jakobson et al.'s work (esp. 1956) remains influential, partly because of their unusual attention to perception. The greatest subsequent influence is that of Chomsky and Halle (esp. 1968, ch. 7), whose system of features has become a touchstone. Their system has, however, been substantially modified, even by those who have considered themselves to be firmly in the generative tradition; and even modified versions face some competition from a more radically phonetic system as represented by dependency phonology (Anderson and Ewen 1987), and feature geometry (Clements 1985).

Many introductions to phonology devote some attention to the Jakobson et al. scheme before surveying the Chomsky and Halle features. Useful reviews can be found in Anderson (1974, appendix), Hyman (1975, ch. 2), Sommerstein (1977, ch. 5), Kenstowicz and Kisseberth (1979, ch. 7), Hawkins (1984, ch. 3), Lass (1984, esp. ch. 5), Odden (2005, ch. 6) and Gussenhoven and Jacobs (2005, ch. 11). Among these, Anderson and Kenstowicz and Kisseberth concentrate on Chomsky and Halle's features; neither survey is uncritical, but Anderson's list should be read with care, as he introduces modifications without identifying precisely where he differs from Chomsky and Halle. The most detailed discussions are found in Sommerstein and Lass. Anderson et al. (1985), Goldsmith (1989), Kenstowicz (1994, esp. chs 1, 4 and 9), Clements and Hume (1995) and Gussenhoven and Jacobs (2005) include more recent perspectives.

Features have also been investigated psycholinguistically under the heading of 'experimental phonology' (section 11.18 below) and Jaeger provides an interesting example of a test to see what kind of 'concept' native speakers have of the feature [voicing] in English (1986, pp. 227–8, 230–1). Fischer-Jørgensen (1985) provides a good example of the way in which features need to be evaluated in the light of linguistic evidence. A summary of the major feature terms and their usage can be found in the tables of appendix 2.

Exercises

1 What is the significance of 'distinctive' in the phrase 'distinctive features'?
2 Do you agree with Sapir that speakers may 'feel' sounds to be something other than what they are in articulatory or acoustic terms? (If you like, discuss his example of English speakers' 'feeling' a velar nasal to be a sequence of [n] and [g].)

3 Consider how each of the following sounds might be specified in terms of features.

   a. [b]
   b. [n]
   c. [s]
   d. [x]
   e. [l]
   f. [u]
   g. [e]
   h. [a]

4 Consider how each of the following classes of sounds might be specified in terms of features.

   a. voiced obstruents
   b. fricatives
   c. lateral consonants
   d. high vowels
   e. back rounded vowels

5 Is there such a thing as a natural class of sounds?
6 Can you find any justification for abstract features which are not definable in acoustic, articulatory or perceptual terms?
7 Should features be true universals or is it legitimate for them to take on (slightly) different meanings when applied to different languages?
8 What criteria should be used to evaluate rival feature systems?

11 The Progress of Phonology

Introduction

This chapter draws the book together, by surveying the theoretical development of the subject. The introductory section (11.1) calls attention to the theoretical underpinnings of phonetics and phonology. Subsequent sections proceed more or less historically through perspectives and schools.

The classic perspectives and terminology were developed in the late nineteenth and first half of the twentieth centuries (11.3–11.8). The second half of the chapter deals mainly with generative phonology (11.9) and elaborations of it or reactions to it (especially 11.10–11.14). The emphasis here is on currents of theory: other chapters give more details of phonemics (chapter 4) and generative phonology (chapter 5).

The topics of the sections are:

- phonetics and phonology before the twentieth century (11.2)
- phonemic phonology (11.3)
- the traditions of phonetics (11.4)
- early North American phonology (11.5)
- the Prague School (11.6)
- glossematics and stratificational phonology (11.7)
- Firthian prosodic phonology (11.8)
- generative phonology (11.9)
- natural generative phonology (11.10)
- natural phonology (11.11)
- autosegmental and CV phonology (11.12)
- metrical phonology (11.13)
- lexical phonology (11.14)
- dependency phonology (11.15)
- optimality theory (11.16)
- prosodic phonology (11.17)
- phonology in the laboratory (11.18).

The conclusion emphasizes the fundamental nature of theoretical discussion in any scientific approach to reality (11.19).