

Abbreviations

| | |
|--------------------------------------|--|
| cm | centimetre |
| cm ² | square centimetre |
| cm ³ | cubic centimetre |
| cm ³ /s | cubic centimetres per second |
| cm H ₂ O | centimetres of water |
| CNS | central nervous system |
| dB | decibel |
| DFT | discrete Fourier transform |
| DL | difference limen |
| DSP | digital signal processing |
| EMA or EMMA | electromagnetic (midsagittal) articulography |
| ERB | equal rectangular bandwidth |
| F ₀ | fundamental frequency |
| F ₁ , F ₂ etc. | first formant, second formant, etc. |
| FFT | fast Fourier transform |
| Hz | hertz |
| IPA | International Phonetic Association |
| JND | just noticeable difference |
| kHz | kilohertz |
| LPC | linear prediction coefficient |
| mm | millimetre |
| mm ² | square millimetre |
| μPa | micropascal |
| m/s | metres per second |
| ms | millisecond |
| mV | millivolt |
| Pa | pascal |
| PNS | peripheral nervous system |
| Psg | subglottal pressure |
| RMS | root mean square (value of sound pressure) |
| RP | Received Pronunciation |
| SPE | <i>The sound pattern of English</i> (Chomsky and Halle 1968) |
| SPL | sound pressure level |
| ToBI | tones and breaks indices |
| VOT | voice onset time |

1 Introduction

1.1 Phonetics and phonology

Phonetics and phonology are concerned with speech – with the ways in which humans produce and hear speech. Talking and listening to each other are so much part of normal life that they often seem unremarkable. Yet, as in any scientific field, the curious investigator finds rich complexity beneath the surface. Even the simplest of conversations – an exchange of short greetings, for example – presupposes that the speaker and hearer make sense to each other and understand each other. Their ability to communicate in this way depends in turn on proper bodily functioning (of brain, lungs, larynx, ears and so on), on recognizing each other's pronunciation and on interpreting the sound waves that travel through the air. The fact that a total outsider, unfamiliar with the language, will find even a simple conversation a bewildering jumble of unpronounceable and unintelligible noise only underlines the extent of our organization and control of talking and listening within particular social and linguistic conventions.

Once we decide to begin an analysis of speech, we can approach it on various levels. At one level, speech is a matter of anatomy and physiology: we can study organs such as tongue and larynx and their function in the production of speech. Taking another perspective, we can focus on the speech sounds produced by these organs – the units that we commonly try to identify by letters, such as a 'b-sound' or an 'm-sound'. But speech is transmitted as sound waves, which means that we can also investigate the properties of the sound waves themselves. Taking yet another approach, the term 'sounds' is a reminder that speech is intended to be heard or perceived and that it is therefore possible to focus on the way in which a listener analyses or processes a sound wave.

The study of these facets of speech is usually termed PHONETICS. Adopting the different perspectives suggested above, phonetics can be viewed as a group of phonetic sciences, separated as ANATOMY AND PHYSIOLOGY OF SPEECH, ARTICULATORY PHONETICS (which often tends to deal with the identification and classification of individual sounds), ACOUSTIC PHONETICS (sometimes restricted to instrumental analysis and measurement of sound waves) and AUDITORY OR PERCEPTUAL PHONETICS. These different aspects of speech are of course integrated: speech sounds cannot be divorced from the organs that articulate

them, a sound wave does not exist in isolation from the source that generates it, and so on.

Moreover, speech is a purposeful human activity: it is not just movement or energy or noise, but a systematically organized activity, intended – under normal circumstances – to convey meaning. The term PHONOLOGY is often associated with the study of this ‘higher’ level of speech organization. Thus phonology is often said to be concerned with the organization of speech within specific languages, or with the systems and patterns of sounds that occur in particular languages. On this view, a general description of how vowel sounds can be made and perceived might be the province of phonetics while the analysis and description of the vowels of English might be assigned to phonology. But both phonetics and phonology have been variously defined and it is impossible to consider such definitions without touching on fundamental questions about the nature of reality and its scientific exploration.

Let us consider some of the observations that phoneticians and phonologists have made about English. First, each English vowel can be said to have a characteristic length. It must be stressed here that we are talking about vowel sounds, not vowel letters; throughout this book, as generally in phonetics and phonology, we use the term VOWEL to refer to a sound, not a letter. Hence in our terms the words *limb*, *hymn*, *live* and *sieve* all contain the same vowel, despite the various spellings. On the other hand, *meat* and *great* contain two different vowels: despite the identical *ea* spelling, the two words do not have the same vowel, a fact which we recognize when we say that the words do not rhyme with each other. Turning now to vowel length in English, the vowel heard in words such as *lip*, *bit*, *miss* is rather short, the vowel of *lap*, *bat*, *lass* is somewhat longer (although its length relative to other vowels varies across different regions of the English-speaking world) and the vowel of *leap*, *beat*, *lease* is longer still. Secondly, whatever their intrinsic or characteristic length, vowels are longer before sounds such as [d] and [g] than they are before sounds such as [t] and [k]. (We follow the usual convention of writing phonetic symbols in square brackets.) If you listen carefully to the pronunciation of words such as *bead*, *greed* and *league*, it should be possible to hear that the vowel is longer than in words such as *beat*, *greet* and *leak*. (If the difference is not very clear, try imagining that you have to contrast two words over the telephone – ‘I said *greet* not *greed*’ – in which case you may find yourself cutting the vowel short in *greet* and exaggerating the length in *greed* as a way of distinguishing the two words.) This is a general pattern of English: any vowel, whatever its intrinsic length, will be longer before certain consonants than before others. Thus the vowel of *beat* is longer than the vowel of *bit*; but *bead* will be even longer than *beat* (as the vowel of *bid* will be longer than that of *bit*, even though it may still be judged a ‘short’ vowel). Thirdly, we can identify the consonants that have a shortening effect on the preceding vowel as ‘voiceless’ – sounds such as [p], [t], [k] and [s] – and those that trigger lengthening as ‘voiced’ – for instance [b], [d], [g] and [z]. Try hissing a lengthened [ssss] and compare it with a lengthened buzzing [zzzz]: the difference between the two is the ‘voicing’ of the [z], a vibration produced in the larynx which is perceived as a ‘buzz’.

Observations such as these are merely the beginning of an account of English speech sounds, but they serve as illustrations. Research which has been concerned with, for example, the precise measurement of vowel length, or the behaviour of the larynx during voicing, or the acoustic consequences of voicing, has generally been considered phonetic research rather than phonological; while research concerned with, for example, identifying and characterizing the total number of distinctive vowels in English, or classifying the sounds of English according to distinctive properties such as voicing or voicelessness, or formulating rules to cover predictable patterns such as vowel lengthening before voiced consonants, has been considered phonological rather than phonetic. As these examples may suggest, phoneticians are likely to draw on methods and techniques used in the natural sciences – precise measurement (say of vowel duration), sampling and averaging (of some measurable value in an acoustic signal) and so on. Phonologists may profess to be more concerned with the mental organization of language – with the systematization of distinctions within a language, for instance, or with the modelling of a speaker’s knowledge as a set of rules.

Unfortunately, what may appear to be a reasonable division of labour between phoneticians and phonologists is frequently discussed in the context of assumptions about the ‘real’ nature of speech. Thus the idea that phonetics is concerned with universal properties of speech, studied by scientific methods, may all too easily be read as a claim that phonetics deals with objective physical or concrete reality, while phonology is somewhat apologetically concerned with the linguistic organization of this reality. Or, more or less reversing the argument, phonology may be said to tackle the true mental reality behind speech, while phonetics handles ‘merely’ the concrete outworkings of this reality. Hence the relationship between phonetics and phonology becomes controversial and it is important to understand the reasons for this, rather than to attempt an oversimplified and divisive definition of the two terms.

In the first place, the frequent stress on the general or universal character of phonetics as opposed to the language-specific focus of phonology is not convincing. While it is true that phonetics often aspires to generalizations about speech organs and acoustics, phonology is often no less interested in generalizing across languages. Any endeavour, for example, to use uniform notation and terminology to describe the phonological organization of various languages suggests an interest in universality. On the other hand, much work in phonetics is quite language-specific – say, studies of the articulation of certain sounds in English – and it would be wrong to suggest that phonetics necessarily has a more universalist character than phonology.

Emphasis on the physical or concrete nature of phonetics must likewise be treated with caution. Of course, one might simply question the terms and ask in what sense a *movement* of the tongue or a sound *wave* is physical or concrete. But it is certainly true that speech organs and sound waves are amenable to observation and measurement in ways that mental organization is not. It is possible, for example, to take ciné X-rays or study magnetic resonance images (MRIs) of the speech organs, to track articulator movement using electromagnetic articulography (EMA or EMMA), to measure muscular activity during

speech and to record the complex sound waves of speech; and observation of this kind is an essential contribution to our understanding of speech. Nevertheless, a ciné X-ray film or a wave pattern tells us very little unless it can be related to the speaker's and hearer's linguistic system. The relatively continuous flow of speech recorded in this way does not of itself display the speaker's organization in terms of syllables or words, or the hearer's perceptual decisions in terms of sounds or categories. Thus while it is true that certain aspects of speech are particularly amenable to certain kinds of quantitative measurement, it would be wrong to conclude that such measurement in itself is sufficient to capture the truth about speech.

On the other hand, talk of linguistic systems and mental organization is open to a different danger, to an assumption that the investigator is now free to speculate about speakers' intuitions and insights. To avoid any misunderstanding here, we stress that any scientific or theoretical investigation of any aspect of speech must be empirical, in other words must be properly based on observation. Empirical standards are perhaps more obvious in respect of articulation and acoustics, where guesswork and speculation defer to the results of properly conducted observation. The same standards nevertheless apply to phonology, where systems and structures need equally to be justified empirically. The techniques may be different – testing speakers' auditory judgements, for example, or observing agreed patterns of rhyme, or noting spelling preferences – but they are or can be none the less empirical.

Furthermore, if it is true that physical records need to be related to linguistic organization, the reverse is no less true. A speaker's intentions or a hearer's perceptual judgements, even when validated empirically, cannot be divorced from the spoken utterances themselves. My belief that I am saying the words 'how are you' on a particular occasion does not pass telepathically from my mind to the hearer's: the message is conveyed by articulated speech and rests on articulatory and acoustic functioning within a linguistic system.

It is not unreasonable, then, to say that phonology deals with the systems and structures of speech, while phonetics focuses more narrowly on articulation and acoustics. But the boundary need not be sharply drawn, nor should it be surreptitiously constructed on assumptions about the primacy of one kind of reality above others. In short, although we analyse speech by breaking it down into its several aspects, we should not forget that the true reality is one of integration.

1.2 Theory and analysis

It is impossible to investigate phonetics and phonology without confronting theoretical issues. In this, phonetics and phonology are no different from other fields of study. Indeed, it is part of the definition of a science – taking the word 'science' in its widest sense to include such areas as psychology and sociology as well as biology and physics – that it is characterized by theoretical reflection. This is not to say that human activities which require little or no theoretical

thinking are worthless or inferior. The skills that humans can develop in, for example, dancing, cooking, gardening or carpentry are a valuable part of the riches of human culture: depending on one's criteria of judgement, they may be enjoyable, useful and, for that matter, well-rewarded activities. But, characteristically, they reflect technical mastery, experience or practical wisdom rather than theoretical understanding.

If we apply this distinction to language and linguistics, it is clear that there are skills, such as mimicry of other accents or languages, which are not scientific in the sense we have outlined. We may, it is true, describe such skills as 'practical phonetics' or 'being a good linguist'. But we may also use the terms 'phonetics' and 'phonology' more narrowly to indicate the theoretically based exploration of spoken language. What is important of course is not so much the terms themselves, but the distinction between speaking, as we all do, with little or no deliberate attention to what we are doing, and analysing the nature of speech, consciously reflecting on the how and why of speaking.

It is significant for linguistic theory that speaking is normally unselfconscious. The integrated nature of language is such that we normally concentrate on meaning and purpose. We are not usually aware of the movements of articulatory organs, we do not keep count of the number of syllables we have uttered, nor do we register whether an utterance happens to have contained particular vowels or consonant clusters. Even when we are alert to speech – for example, when we are conscious of tripping over certain words or sounds in our own speech, or when we register the 'strange' accent of another's speech – our impressions almost always remain subordinate to questions of meaning. It is rare, and verging on the pathological if, for example, we are so selfconscious about our articulation that we lose track of what we want to say.

The theoretical significance of this point is that it puts both our everyday use of language and our scientific investigation of it into perspective and enables us to relate the two to each other. Speakers talk, say things, convey their meaning; they do not, from their own habitual perspective, make articulatory movements or initiate sound waves. But the linguist, as a scientist, is interested in precisely these constituent processes and activities which are not the speaker's focus of attention but which make it possible for speakers to say what they mean. In phonetics and phonology we analyse what goes on in everyday speaking, resolving the integrated complexity into its different aspects, breaking down the overall activity into its component details, explaining how the deceptive simplicity of the everyday is achieved. The analysis is neither better nor worse than the activity itself: it attempts to explain and explore.

What we have been saying so far is itself part of a theory (and therefore open to debate). Our view can be described as functional, in that we assume that language has the ultimate function of being meaningful and that the task of analysis is to investigate how that function is achieved through subsidiary functions. Thus speakers function characteristically in terms of meaning. They function also as biological mechanisms (using muscles to bring articulatory organs into place), as psychological subjects (perceiving and discriminating speech sounds) and so on. But these functions are harnessed to the overall goal of meaningful interaction with other humans.

Finally, it must be stressed that scientific knowledge and analysis are always provisional. As we shall see later, twentieth-century phonology was regrettably often characterized by a polemical style in which certain insights or perspectives are proclaimed to the exclusion of all others. The inevitable consequence is that a distorted theory enjoys a brief spell as ultimate truth before falling prey to the next 'ultimate' alternative. To pursue absolute truth is one thing; to possess it quite another.

1.3 Applications of phonetics and phonology

Phonetics and phonology intersect with a number of interests, partly because of the theoretical connections between aspects of speech and other scientific fields of study, partly because of various practical motives that have drawn on or stimulated speech research.

Interest in recording and describing pronunciation has a long history. A concern to record dialect pronunciations, for example, was an important factor in the development of modern phonetic transcription. The consequent interest in the amount of detail that could be included in a transcription also contributed to phonological theory. Similar interest in recording hitherto unwritten languages, such as the indigenous languages of the Americas, was often combined with a desire to devise practical orthographies and to promote literacy. So strong was this motive that some linguists almost equated phonology with a set of techniques for reducing languages to writing. In fact the relationship between spoken and written language is not necessarily direct and the conception of phonology as the art of orthography design is far too narrow. Nevertheless, the study of phonetics and phonology is certainly relevant to questions of writing and spelling: it is probably fair to say, for example, that many teachers responsible for introducing children to reading and writing in English-speaking countries are insufficiently informed about actual pronunciations and often fail to appreciate the reasons for some of the problems experienced by children (such as confusion of spelling between *chain* and *train* or uncertainty about which vowel to write before *l* in *bolt* or *salt*). Moreover, many of the world's languages do have spelling systems that were deliberately designed to reflect pronunciation (sometimes misleadingly called 'phonetic spelling systems') and others have been reformed from time to time to keep them closer to actual pronunciation.

Language teaching has also contributed to and profited from phonetics and phonology. Many works on English phonetics and phonology have been written for the benefit of foreign learners, for example. The fact that English spelling is not a direct reflection of pronunciation has undoubtedly been an important factor here and has led to the publication of pronouncing dictionaries and other guides to pronunciations, both for native speakers of English and for learners. It is now customary for general-purpose English dictionaries to include some kind of transcription or guide to the pronunciation of each word (a practice

which is by no means standard for other languages with more consistent spelling conventions). Debate about a standardized or 'correct' pronunciation of English has also played an important role, and much of the work on phonetics in Britain in the first half of the twentieth century was oriented towards the description and promotion of so-called Received Pronunciation (RP), a style of pronunciation more commonly and less precisely referred to as 'BBC English' or 'Oxford English'.

Information about speech and pronunciation is thus of some general interest to users of language and of specific importance to those engaged in recording, describing and teaching languages. Certain other professions are directly concerned with speech and hearing, notably audiology and speech therapy or speech pathology. A solid grounding in phonetics and phonology is normally an integral part of the training for these professions, and practice and research in these fields have also contributed to the development of phonetics and phonology.

Advances in technology in the twentieth and twenty-first centuries have opened up new ways of investigating the articulatory and acoustic properties of speech and have substantially enlarged the scope of phonetics. This continually widening field of instrumental research has not only made it possible to improve upon some of the earlier impressionistic observations about speech, but has also brought about interaction with other areas of research such as physiology, behavioural science, physics, electronics and software engineering. There are now promising developments in, for example, the generation of synthetic speech ('machines that talk') and the conversion of speech to text ('machines that type what they hear'), and in spoken dialogue systems which bring both together. Research of this kind has commercial potential as well as theoretical fascination and it brings phoneticians and phonologists together with experts in language technology, computing and artificial intelligence.

1.4 Outline of this book

We make no apology for devoting a large proportion of this book to what may seem to be technicalities. Chapters 2 and 3 are intended to provide a solid foundation of insight into the complexity of human speech, with detailed attention to the great diversity of speech sounds that can be found in the world's languages. Chapter 4 deals with some basic principles of phonological organization, in fairly traditional terms, while chapter 5 outlines the generative approach to phonology, which has rivalled more traditional concepts since the 1960s. Chapter 6 introduces relevant aspects of anatomy and physiology, exploring the structure and function of the organs of speech. Chapter 7 is a detailed account of the acoustics of speech and chapter 8 deals with the perception of speech. The two following chapters cover prosody (notably the phenomena of stress, tone and intonation: chapter 9) and the categorization of speech sounds into component features (chapter 10). Chapter 11 draws the book together by looking back over the theoretical issues that have been raised and by giving a

historical survey of ways of thinking and talking about speech, from the earliest times through to current attempts to refine theory and description.

Diagrams and small tables are included in the text wherever they help to illustrate a point. Phonetic symbols and features are also set out in the appendices, where they can be readily identified and referred to.

The organization of the book is somewhat unusual, and is deliberately intended to blur some of the boundaries which are often inflicted on phonetics and phonology. It might have been more in keeping with tradition to proceed through the 'phonetics' of speech (articulation and acoustics) to a review of schools of phonology and modern descriptive approaches in historical order. We have not done so precisely because we want to stress that there are no uncontroversial 'facts' of speech that are independent of questions about how to understand and describe them. Indeed, contrary to a common assumption, there is no simple theoretical progression from elementary and obvious truth to abstract and contentious theorizing, nor a straightforward historical progression from past ignorance to present or future omniscience.

To take just one example, it may seem obvious and indisputable that all speech sounds are either consonants or vowels. The moment one probes this statement, however, it turns out to raise all kinds of questions. Speakers of English first have to ensure that they distinguish between letters and sounds. Words such as *myth* and *hymn* certainly contain a vowel (the same vowel as in *pith* and *him*), despite the fact that they happen not to use the letter *i*, while words such as *union* and *usage* begin with a consonant (the same that begins *you* and *youth*), as is evident from the fact that we say *a union*, not *an union*. Having focused on pronunciation rather than spelling, we confront a series of questions: what criteria are actually used to classify sounds as consonants or vowels? Are there no other possibilities – sounds which are intermediate in nature between consonant and vowel or neither one nor the other? What of the consonant-like transition between the first two syllables of words such as *Diana*, *hyena* and *Guyana* – is there a consonantal *y*-sound here or not, and by what criteria can this question be answered? And so on. It is enough here to note that a simple assertion about consonants and vowels, if intended as part of a serious description of language, rests on assumptions about categories and criteria of description, assumptions which are theoretical in their import.

When challenging apparent simplicity and teasing out assumptions in this way, one could begin almost anywhere – with a detailed look at what makes a vowel a vowel, with a question about conventional spellings, with a particularly problematic example, among other possibilities. But because language itself is an integrated human activity the line of investigation will lead on into related questions and assumptions. And so it is with the entire domain of phonetics and phonology. Beginning with a broad theoretical framework would mean that essential detail has to be filled in later, while beginning with the details of how sounds are made would mean that other equally essential considerations are inevitably deferred. Thus we ask the reader not just to accept that the progression of this book may not seem ideally logical, but to enjoy the realization that there are limitations on our ability to cut up and package neatly a reality whose parts are interrelated.

Exercises

- 1 Take as much time as you can to study discrepancies between the spelling and pronunciation of English. You may like to consider:
 - a. words which look similar but are pronounced differently, such as *bough*, *cough*, *rough*, *through*, or *done*, *gone*, *tone*;
 - b. words which look different but are pronounced identically, such as *right*, *rite*, *write*, or *seas*, *sees*, *seize*;
 - c. words which are written differently in different parts of the world or for different purposes, such as *color*, *colour* or *through*, *thru* or *check*, *cheque*;
 - d. words which appear to be regular words in an informal or eye-catching respelling, such as *bar-b-q*, *eez*, *kleen*, *kwik*.
- 2 Try to identify the way of pronouncing English known as RP, or Received Pronunciation. (Speakers of RP include many members of the British royal family and aristocracy.) As far as you can, note any major systematic differences between RP and your own pronunciation of English.
- 3 What is your own attitude to different ways of pronouncing English? Do you consider some pronunciations are better or more correct than others? Do you consider that everyone – even those who learn English as adults – should speak with one and the same accent?
- 4 Put the following words and names into sets sharing the same vowel. Group the words by pronunciation, not spelling: *Joan*, *mode*, *woad* should be one of your sets, and *den*, *head*, *wed* another. Bear in mind that there are systematic differences among speakers of English, so not everyone will group the words in the same way.

Dan, Dane, darn, dawn, dean, den, din, dine, Don, done, down, gin, had, hard, head, heed, herd, hid, hide, hoard, hood, Jan, Jane, Jean, Joan, John, join, June, mad, made, mid, mode, mood, mud, vied, void, vowed, wad, wade, wed, weed, wide, woad, wood, wooed, word.
- 5 Put the following words into sets sharing the same initial consonant. Group the words by pronunciation, not spelling.

call, cat, ceiling, cell, chemist, gnat, go, guest, gull, guy, keel, key, knee, kneel, know, nemesis, nine, no, quay, sat, sea, sell, sigh, so.