

have in each case tried to rethink, through our examination of contrasts in languages, the basis on which any given one is justified. We also discuss the relationship that exists between the phonetic categories we establish and the classificatory features employed in phonological theory. In these discussions we take as our usual point of reference the features that have been used in recent models of feature geometry (see the review by McCarthy 1988), although we also pay some attention to some older proposals and certain newer suggestions. We do not attempt to present our own competing phonological feature system, as we are not examining phonological processes and constraints, but only contrasts (and even these from a largely phonetic point of view). We do, however, point to some areas where we believe that some elaboration or clarification of the usual feature scheme might be advisable. In the Coda at the end of the book we summarize the major findings on segmental contrasts which a phonological theory must address.

We also maintain that a distinction can be drawn between those phonetic parameters that are likely to serve as a basis for the organization of linguistic behavior, and others that can be used to provide a physical characterization of sounds, but which do not relate well to the sound patterns of languages. We could, for example, consider place of articulation to be defined in terms of a single continuous parameter such as the distance of the stricture from the glottis. However, this description would overlook, among other things, the functional and anatomical separation that exists between the lips and the tongue. A more insightful description is therefore one that partitions place of articulation into a number of major zones, within each of which certain categories can be distinguished.

As is detailed in our discussion of place of articulation in chapter 2, this does not mean that boundaries between each category can be easily determined. For example, the tongue has no clearly defined regions, and neither does the roof of the mouth; and there are, of course, similar problems in dividing the continua which underlie other phonetic parameters. Nonetheless, it is very striking that languages often seem to cut the continua in similar ways so that it is possible to equate a sound in one language with a similar sound in another. Our procedure in trying to build up a description of the sounds of the world's

1			Bl
2	Al	=	B2
3	A2	=	B3
4	A3		

The likely total of contrastive categories along a given parameter is established by considering a set of such equivalences. Of course, judging which two sounds in different languages are equivalent rests on both the evaluation of data and experience.

A particular speech sound is not characterized by a value on only one parameter, but by the set of specified values on all the relevant parameters. We organize our discussion primarily on the basis of integral sounds, not according to single parameters or groups of related parameters. For example, there are chapters devoted to stops, nasals, fricatives, and vowels, rather than chapters which discuss topics such as degrees of stricture, types of phonation, and lip position. There is one significant exception to this general practice: In chapter 2 we survey the places of articulation needed to characterize the sounds of the world's languages, focussing on place contrasts found in stops and nasals. This chapter provides a framework for description of place contrasts among other classes of segments.

The next chapter, chapter 3, describes the remaining aspects of the various types of stops that occur (apart from clicks, to which a separate chapter is devoted). This chapter contains the principal discussion of distinctions in laryngeal activity between segments. The four succeeding chapters discuss other major types of consonants - nasals, fricatives, laterals and rhotics - in terms of the distinctions in place and laryngeal activity previously established, as well as any additional parameters that relate to the specific class of consonants covered by the chapter. Chapter 8 is devoted to clicks. Although sounds of this type occur in relatively few of the world's languages, there is great variety among clicks due to the fact that a large number of ways of modifying them are employed in the languages that use them. The survey then continues with a chapter on the vowels and semivowels observed in the world's languages. A final chapter on high-level topics discusses some broader issues that should

distinguishing the meanings of words or phrases. That is, a phonetic theory should be able to make a distinction between those properties of sounds that can or could convey linguistic information (the difference between one form and another within a possible language) and those that convey only sociolinguistic information (the difference between one language or dialect and another). We believe that it is possible to set up a system of phonetic parameters each of which contains categories that taken as a whole, will distinguish all the potential contrasts within human languages. The system also allows for differences between one language and another to be described by different values along the parameters.

In addition to the categories and parameters of our descriptions we sometimes refer to targets or gestures in our accounts of segments. We would like to make clear that we are using these terms without implying any specific theoretical framework. A target can be thought of as either a specific location towards which an articulator is moving or as a more general notion including several properties such as the rate of the movement or its acoustic results. In either case, a target is an abstract goal at which one aims but which one does not necessarily hit. A gesture in our usage is a movement of a single articulator, which may by itself form the basis of a segment, or may require coordination with other articulatory movements for the formation of the sound. This is not the same concept as used in Articulatory Phonology (Browman and Goldstein 1992) but is based on similar insights. We adopt this usage to provide a framework within which to discuss dynamic aspects of speech. Speech is not a static process, but an active one, and it is clear that many properties cannot be understood unless we examine their dynamic aspects.

Although the discussion in this introductory chapter and the general layout of this book are in terms of articulatory properties of sounds, throughout the book we have also taken note of acoustic properties. It is perfectly possible to describe all the systematic phonetic contrasts that occur among languages in terms of the sound-producing mechanism. But this is often not the appropriate way of characterizing contrasts; some phonological statements depend more

far wider range of languages than others. We do not at the moment have a complete theory that will account for these facts. There is no doubt that some articulations are easier to make than others. Thus although it is perfectly possible for anybody to make a closure between the blade of the tongue and the upper lip, this gesture is not used in many languages, perhaps because it is harder to integrate into the stream of speech than, say, a bilabial stop. There is also no doubt that some auditory distinctions are easier to maintain than others; the set of vowels i, e, a, o, u are more distinct than the set y, ə, a, x, ui. Furthermore, as Stevens (1989) has pointed out, some articulatory gestures can vary over a fairly wide range without producing much acoustic change, resulting in what he calls quantal articulations. But while pursuing these topics is undoubtedly of great importance for an adequate theory of phonetics, our aim in this book is more limited, and we will comment on them only in passing.

We have attempted to provide a great deal of documentation of the contrasts we discuss. As a result, we believe that a part of the value of the book lies in its exemplification of a wide variety of types of phonetic data collected by a range of techniques. The data includes still and cine x-ray photography, palatography, spectrograms, waveforms, aerodynamic data, and articulatory movement data obtained by a number of different methods. We have not attempted to explain how to use these methods, as this book is not a handbook of phonetics, but we hope that we have provided sufficient pointers so that readers will understand the significant aspects of the documentation provided. Readers are presumed to be familiar with basic phonetic concepts as expounded in standard textbooks. We are, however, aware that we refer to so many languages that readers are unlikely to be familiar with all of them. With this in mind, we provide an appendix identifying the location and classification of all languages mentioned. In the text itself languages will usually be cited without further identification.

As with any jointly authored work, this book represents the results of some compromises between the authors. Had only one of us been writing the book, some data would have been interpreted differently, and certain arguments would undoubtedly have been stated more forcefully than they appear here, while others would have been omitted altogether. But such deliberations

particular sounds cited could be obtained from our own resources. The great wealth of material available to us led to some problems in trying to decide which of many pieces of data we should include-. We wanted to write a book that would advance linguistic and phonetic theory. Accordingly we have limited ourselves to discussing just the data required for this purpose. We have not included a number of things that are well known and readily available, such as acoustic data illustrating the contrasting stop consonants in English, or extended discussions of voice onset time.

As our research went on, we also uncovered some notable gaps in the available published data and our own resources. This led to an interesting problem in research management. To what extent should we try to fill these gaps by extending our own investigations? Our solution to this problem was to set a date for the completion of this book, and do what we could within this time limit. As a result we are woefully aware that much more could have been done. We have been able to provide a large number of new analyses of our own previously unpublished data, and to summarize much of the literature. But we can still foresee a lifetime of work ahead of us.

This is the present state of our knowledge about the linguistic phonetic events that occur in the languages of the world.

R|

Places of Articulation

In this chapter we will describe the range of different locations within the oral cavity at which the major articulatory events involved in consonant production may occur. This is, in traditional terms, the place of articulation. We will be concerned mainly with stops and nasals, in that we will usually be considering complete closures of the vocal tract. This is in part because it is more straightforward to characterize the location of a closure than to describe the location of a stricture of lesser degree. However, some additional locations are used for fricatives, and where necessary we will supplement our account by describing these sounds. We will also note in Chapter 5, in which we discuss fricatives in more detail, that there are some interrelationships between place of articulation and manner of constriction. In the present chapter we will describe the primary components of each movement, neglecting any secondary articulations. We will also neglect aspects of the vocal tract that are associated with the phonatory activity of the glottis or with the velic opening. All these additional components of sounds will be discussed in subsequent chapters.

equation describing its motion, this would not be very insightful. What is of prime importance in the phonetic patterning of languages is the *outcome* of a set of movements. For example, closing the lips always involves some movement of the lower lip. However, the extent to which the lower lip is moved independently or is moved by raising the jaw may vary, and the amount that the upper lip is lowered to meet the lower lip may vary as well. Although understanding how the trade-off between these different possibilities is managed is very important for building a model of how speech activity is actually controlled, such detail is not of any linguistic significance. What matters is the fact that the lips close - the important variable might be labeled lip aperture.

A set of possible linguistically relevant variables of this kind has been proposed by Browman and Goldstein (1986,1992) in their Articulatory Phonology model. The most significant part of the Articulatory Phonology research program is the central role that is assigned to the dynamics of the articulation. Movements are described in terms of abstract gestural prototypes. These have an inherent time-course and are coordinated with other gestures so that different degrees of temporal overlap can be specified. Our view of speech activity' is colored by Browman and Goldstein's work, although we believe that the number of variables needs to be larger in order to deal with the full range of distinct sound types used in the languages of the world, and our use of the term 'gesture' is not exactly the same as theirs. We do not assign any formal theoretical status to gestures, but use the term gesture to refer to a generalized pattern of movement for a family of linguistically equivalent articulations. In what follows we will concentrate on describing the articulators used and the directions of the movements in each gesture understood in this sense.

We will describe articulations in terms of the five major parts of the vocal tract that move. These are shown in figure 2.1 in a sagittal section of the vocal tract. These moveable parts can be called the active articulators. The first set of articulators consists of both the upper and lower lip. There is no doubt that movements of the upper lip play a prominent role in some articulatory gestures, but the larger movements are those of the lower lip, which is often raised

are said to be apical. The underside of the tip of the tongue is used in some articulations; sounds made in this way are said to be sub-apical. Behind the tip is the blade, which is the defining part of the tongue for sounds that are said to be laminal. It is difficult to say how far back the blade extends. Probably the most useful definition of the blade of the tongue from a linguistic phonetic point of view is in terms of its relation to the roof of the mouth. It is the part of the tongue below the center of the alveolar ridge when the tongue is at rest. This, of course, requires us to define the alveolar ridge - an equally difficult task. The center of the ridge is the point of maximum slope in the curvature of that part of the midline sagittal section of the vocal tract which is behind the upper teeth. In practice this is often difficult to determine but it is probably the most useful point that can be approximated in a wide selection of individuals. Laminal sounds are made with the part of the tongue that has its center, when the tongue is at rest, immediately below the center of the alveolar ridge. The laminal area extends forward to about 2 mm behind the tip of the tongue, and backward to a point about 2 mm behind the point on the tongue below the center of the alveolar ridge. The tip and blade of the tongue form Coronal articulations.

The body of the tongue is the mass of the tongue behind the blade which can be taken to have its effective center in the neighborhood of the point labeled 'body' on figure 2.1. From an articulatory point of view, it is the surface of this mass that has to be considered. Articulations made with this surface are said to be Dorsal articulations. It is sometimes useful to distinguish between the front and back regions of this surface, the front being that part which is at rest below the hard palate and the back that part which is at rest below the velum. These regions cannot be moved separately from each other.

The root of the tongue and the epiglottis can be moved independently of the body of the tongue, although, as with other articulations involving the tongue, when they are moved the rest of the tongue will be moved with them. The relation between the root of the tongue and the epiglottis is similar to that between the tip and blade of the tongue. They can be moved separately, but

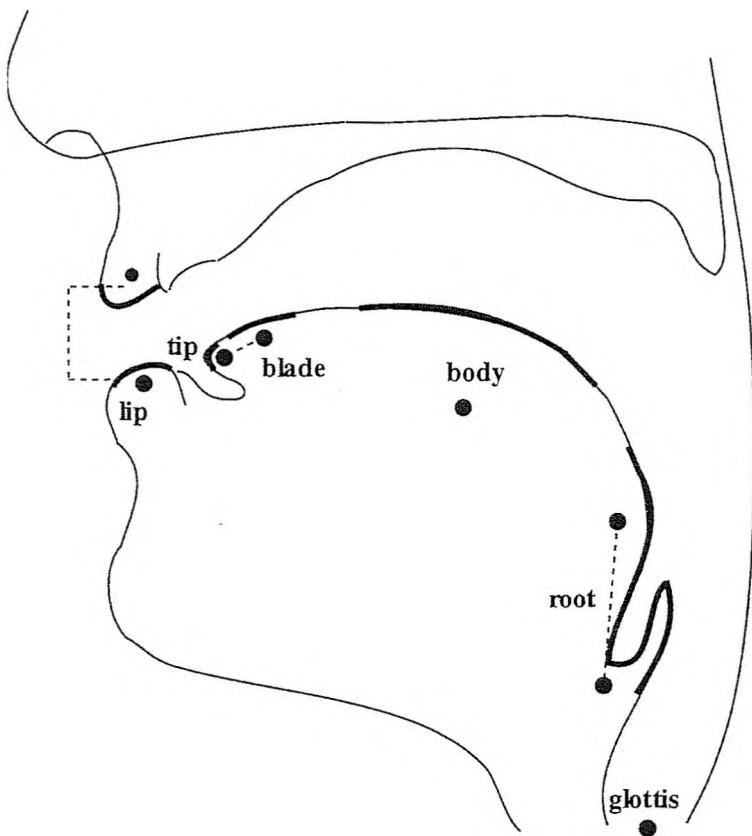


Figure 2.1 The five groups of moveable structures forming the active articulators in the vocal tract.

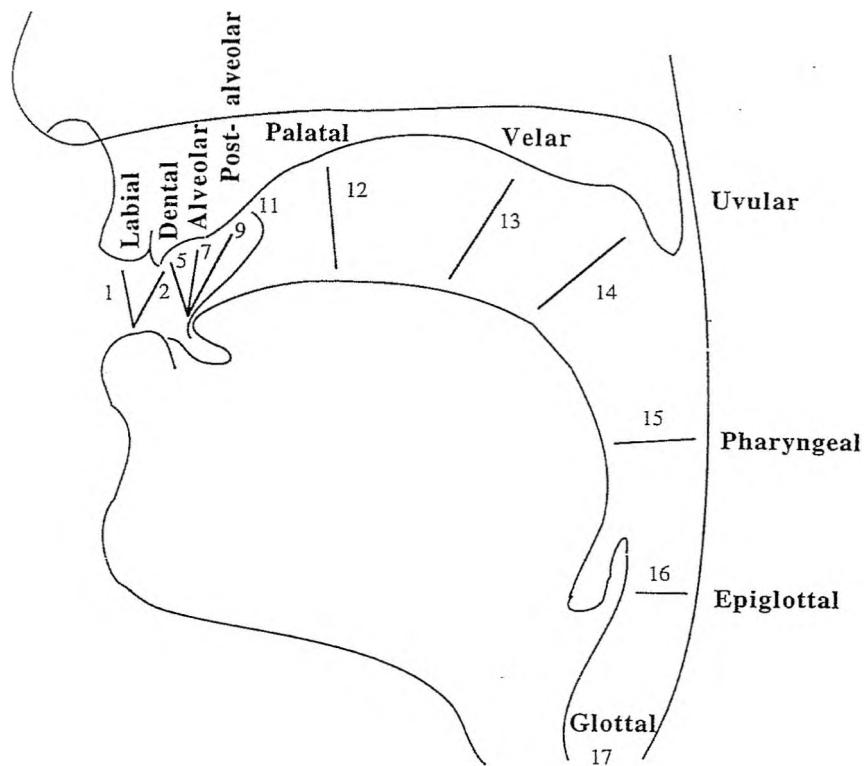


Figure 2.2 The nine regions of the vocal tract that can be considered as target areas for the moveable articulators. The numbered lines show some of the 17 named articulatory gestures, including those in the glottal region. Some additional gestures are shown in the more detailed diagrams of the anterior part of the vocal tract in Figure 2.3.