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## Introductory Phonology

Bruce Hayes

 **WILEY-BLACKWELL**

A John Wiley & Sons, Ltd., Publication

This edition first published 2009  
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Blackwell Publishing was acquired by John Wiley & Sons in February 2007. Blackwell's publishing program has been merged with Wiley's global Scientific, Technical, and Medical business to form Wiley-Blackwell.

*Registered Office*

John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, United Kingdom

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*Library of Congress Cataloging-in-Publication Data*

Hayes, Bruce, 1955–

Introductory phonology / Bruce Hayes.

p. cm. – (Blackwell textbooks in linguistics ; 23)

Includes bibliographical references and index.

ISBN 978-1-4051-8411-3 (pbk. : alk. paper) – ISBN 978-1-4051-8412-0 (hardcover : alk. paper)

1. Grammar, Comparative and general–Phonology. I. Title.

P217.H346 2009

415–dc22

2008009666

A catalogue record for this book is available from the British Library.

Set in 10/13 point Sabon by Graphicraft Limited, Hong Kong

Printed in Singapore by Markono Print Media Pte Ltd

1 2009

For Pat and Peter

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## Preface

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This text is meant as a first course book in phonology. The book has evolved as the textbook for a course taught to a mostly undergraduate audience over a number of years in the Department of Linguistics at UCLA. The course meets in lecture for four hours per week, with a one-hour problem-solving session, during a ten-week term.

The ideal audience for this book is a student who has studied some linguistics before (and thus has some idea of what linguists are trying to accomplish), and has already taken a course in general phonetics, covering at least the basics of articulatory phonetics and the International Phonetic Alphabet. It is possible to make up this material on the fly through reading and practice,<sup>1</sup> but I consider this strategy second-best. A short chapter on phonetics, intended for review, is included in this text.

As the title implies, this book is meant to be an introductory text. By this I mean not that it is meant to be easier than other texts, but rather that it emphasizes the following two things:

- **Analysis of phonological data**, along with methods that experience has shown can be useful in leading to accurate analyses.
- The **scientific context** of phonological analysis: what are we trying to understand when we carry out formal analyses of the phonological patterns of languages?

I consider the first item to be crucial in an introductory course, because if analysis is not well done at a basic level, all of the more sophisticated theoretical conclusions that might be drawn from it become untrustable. The second item is likewise crucial, to make phonological analysis meaningful.

As a consequence of these general goals, I have left out quite a few topics that currently are of great interest to many phonologists, myself included. This reflects

<sup>1</sup> Some recommended material for this purpose: Peter Ladefoged, *A Course in Phonetics* (5th ed., 2005, Heinle), and the accompanying sound materials made available at <http://hctv.humnet.ucla.edu/departments/linguistics/VowelsandConsonants>.

my goal of teaching first the material that will provide the most solid foundation for more advanced theoretical study.<sup>2</sup>

I have tried to avoid a common problem of linguistics textbooks, that of presenting data simplified for pedagogical purposes without providing some means for the student to access more information about the language. This is provided in the “Further reading” section at the end of each chapter.

A number of passages in the text offer guidance in eliciting useful and valid data from native speakers. This relates to the phonology course I teach, in which one of the major assignments is a term paper involving analysis of data gathered first hand from a native speaker.

A computer resource for phonology that I have found useful in conjunction with this text is **UCLA FeaturePad**, a computer program created by Kie Zuraw, which helps students to learn and use features by showing the natural classes that correspond to any selection of feature values. It also shows how the sounds are changed when any feature values are changed. The program may be downloaded for free from [www.linguistics.ucla.edu/people/hayes/120a/](http://www.linguistics.ucla.edu/people/hayes/120a/).

Many people provided me with help and feedback on this text, for which I am very grateful. Among them were Marco Baroni, Christine Bartels, Roger Billerey, Abigail Cohn, Maria Gouskova, Jongho Jun, Sun-Ah Jun, Patricia Keating, Charles Kisseberth, the late Peter Ladefoged, Lisa Lavoie, Margaret MacEachern, Donka Minkova, Susan Moskwa, Pamela Munro, Russell Schuh, Shabnam Shademan, Bernard Tranel, Adam Ussishkin, Keli Vaughan, and Kie Zuraw. I’m certain that I’ve left names out here, and in cases where my memory has failed me I hope the unthanked person will understand.

I welcome comments and error corrections concerning this text, which may be sent to [bhayes@humnet.ucla.edu](mailto:bhayes@humnet.ucla.edu) or Department of Linguistics, UCLA, Los Angeles, CA 90095-1543.

For sound files, updated web links, typo corrections, and other material, please visit the website for this text at [www.linguistics.ucla.edu/people/hayes/IP](http://www.linguistics.ucla.edu/people/hayes/IP).

Portions of chapters 2, 3, 6, and 7 appeared in earlier form as chapter 12 of *Linguistics: An Introduction to Linguistic Theory* by Victoria Fromkin et al. (2000, Blackwell).

<sup>2</sup> For students going on to more advanced topics, I have found the following texts to be helpful: John Goldsmith, *Autosegmental and Metrical Phonology* (1990, Basil Blackwell); Michael Kenstowicz, *Phonology in Generative Grammar* (1994, Basil Blackwell); René Kager, *Optimality Theory* (1999, Cambridge University Press); John McCarthy, *A Thematic Guide to Optimality Theory* (2002, Blackwell).

# 1 Phonetics

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## 1.1 Phonetics and Phonology

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There are two branches of linguistic science that deal with speech sounds: **phonetics** and **phonology**.

Phonetics is primarily an experimental science, which studies speech sounds from three viewpoints:

- **Production:** how sounds are made in the human vocal tract
- **Acoustics:** the study of the waveforms by which speech is transmitted through the atmosphere
- **Perception:** how the incoming acoustic signal is processed to detect the sound sequence originally intended by the speaker

Phonology is also, sometimes, an experimental science, though it also involves a fair degree of formal analysis and abstract theorizing. The primary data on which phonological theory rests are phonetic data, that is, observations of the phonetic form of utterances. The goal of phonology is to understand the tacit system of rules that the speaker uses in apprehending and manipulating the sounds of her language (more on this in chapter 2).

Since phonological data are phonetic, and since (as we will see) the very nature of phonological rules depends on phonetics, it is appropriate for beginning students to study phonetics first. In particular, a phonologist who tries to elicit data from native speakers without prior training in the production and perception of speech sounds will be likely to have a hard time. The material that follows can be taken to be a quick review of phonetics, or else a very quick introduction that can be amplified with reading and practical training from materials such as those listed at the end of the chapter.

In principle, a phonologist should understand all three of the areas of phonetics listed above: production, acoustics, and perception. Of these, production probably has the greatest practical importance for the study of phonology. Since it is also the simplest to describe, it is what will be covered here.

## 1.2 The Vocal Tract

The term “vocal tract” designates all the portions of the human anatomy through which air flows in the course of speech production (see figure 1.1). These include (from bottom to top):

- The lungs and lower respiratory passages
- The **larynx** (colloquially: “voice box”). This is the primary (but not the only) source of sound in speech production
- The passages above the larynx, called the **pharynx**, **oral cavity** (mouth), and **nasal cavity**

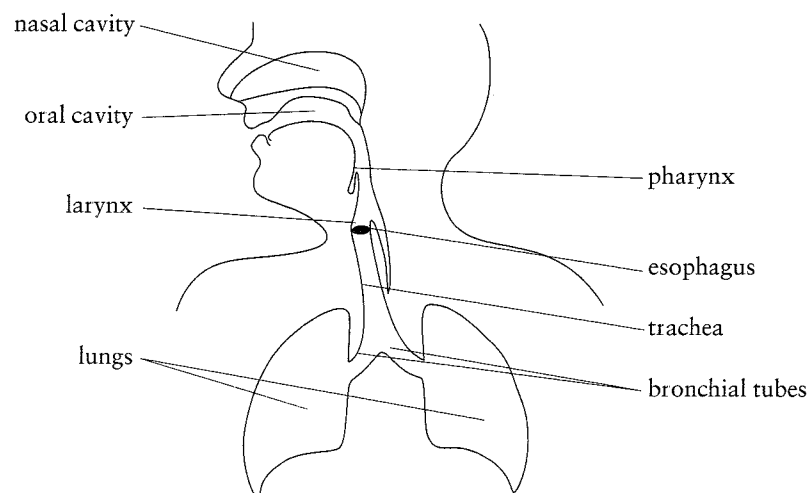


Figure 1.1 The vocal tract

The lungs and respiratory muscles produce a fairly steady level of air pressure, which powers the creation of sound. There are occasional momentary peaks of pressure for certain speech sounds and for emphatically stressed syllables. Air from the lungs ascends through the **bronchial tubes**, which join to form the **trachea** (windpipe). The bronchial tubes and the trachea form an inverted Y-shape.

### 1.2.1 The larynx

The larynx is a complex structure of cartilage and muscle, located in the neck and partly visible in adult males (whose larynxes are the largest) as the “Adam’s apple.” Figure 1.2 shows two diagrams of the larynx:

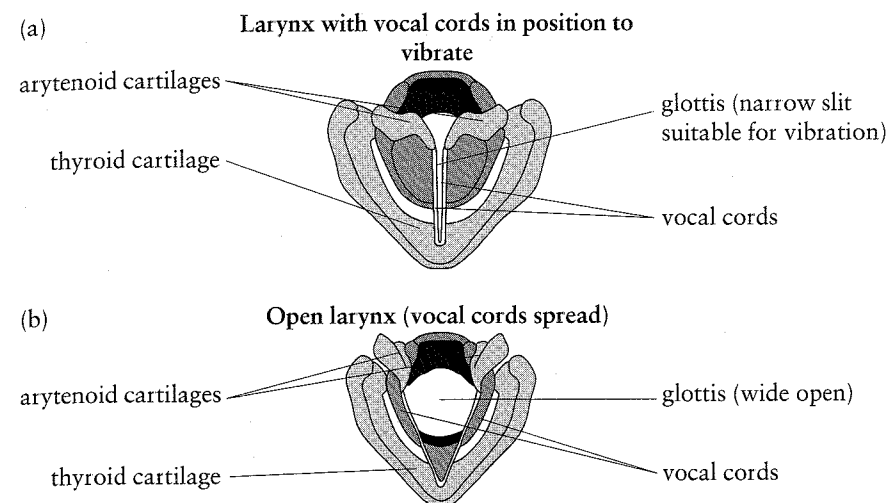


Figure 1.2 The larynx

The larynx contains the **vocal cords** (not “chords”), which are parallel flaps of tissue extending from each side of the interior larynx wall. The vocal cords have a slit between them, called the **glottis**. The vocal cords are held at their rear ends by two small cartilages called the **arytenoid cartilages**. Since these cartilages are mobile, they can be used to adjust the distance between the vocal cords.

When the vocal cords are held tightly together, the sound known as a **glottal stop** is produced; it can be heard in the middle of the expression “uh-oh” and is used as a speech sound in many languages.

If the vocal cords are placed close to each other but not tightly shut, and there is sufficient airflow from the lungs, then the vocal cords will vibrate, creating **voicing**. This is the configuration shown in figure 1.2(a). Voicing is the most important and noticeable sound source in speech.

The vocal cords can also be spread somewhat apart, so that air passing through the glottis creates turbulent noise. This is the way an “h” sound is produced. The vocal cords are spread farther still for normal breathing, in which airflow through the larynx is smooth and silent. This is the configuration shown in figure 1.2(b).

The cartilages of the larynx, especially the **thyroid cartilage** to which the front ends of the vocal cords attach, can stretch and slacken the vocal cords, thus raising and lowering the pitch of the voice. This is somewhat analogous to the changes in pitch that occur when a guitar string is tightened or loosened.

### 1.2.2 The upper vocal tract

Sound created at the larynx is modified and filtered as it passes through the upper vocal tract. This area is the most complex and needs the most detailed discussion; you should refer to figure 1.3 while reading the text.

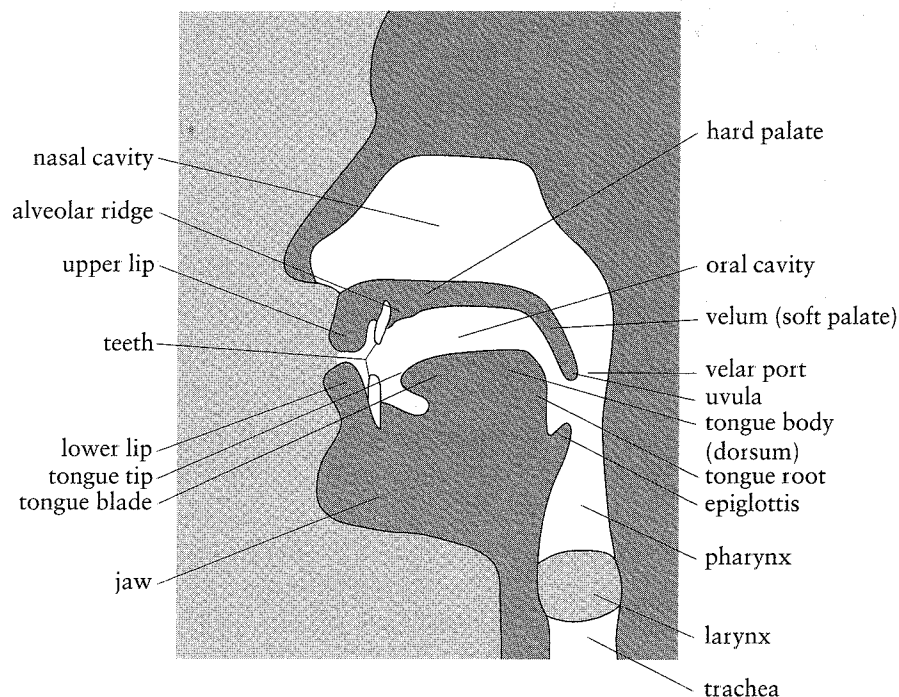


Figure 1.3 The upper vocal tract

The main route through the upper vocal tract is a kind of arch, starting vertically upward from the larynx and bending forward through the mouth. There is an opening about half way from larynx to lips, called the **velar port**, through which air can pass into the nasal passage and outward through the nostrils. In figure 1.3, the velar port is wide open.

We will first cover the upper surface of the upper vocal tract (the roof of the mouth and the back of the pharynx), then the lower surface (floor of mouth, continued as the front wall of the pharynx).

Going in the “upstream” direction, the crucial landmarks of the upper surface are:

- The upper lip.
- The upper teeth (in particular, the incisors).
- The **alveolar ridge**, a bony ridge just behind the base of the upper incisors. Most people can feel their alveolar ridge by moving the tongue along the roof of the mouth.<sup>1</sup>

<sup>1</sup> Some people do not have a sharply defined alveolar ridge.

- The **hard palate**, which is that part of the roof of the mouth underlain by bone. You can feel the hard palate, and its rear edge, with the tip of your tongue.
- The **velum**, or **soft palate**. This is a flap of soft tissue that separates the mouth from the nasal passages. It is attached at the front (to the hard palate) and at the sides, but hangs loose at its rear edge. Various muscles can raise and lower the velum. When the velum is high, then the velar port is closed, and air is confined to the oral passage.<sup>2</sup>
- The **uvula** ([ˈjuːvjələ]). The little thing that dangles from the rear edge of the velum is called the uvula, Latin for ‘little grape’. The uvula is vibrated (trilled) as a speech sound in some languages.
- The **pharynx**. Once we are past the velum, we are no longer in the mouth proper but in the rearward part of the upper vocal tract, commonly called the pharynx. The rear pharyngeal wall is continuous and has no significant landmarks all the way down to the larynx.

The crucial parts of the lower surface of the upper vocal tract are as follows:

- The lower lip and the tongue rest on the **jaw**, which raises and lowers the lower lip and tongue when it moves during speech.
- The **lower lip** is more mobile than the **upper** in speaking, though both move considerably. They can touch one another, closing the mouth, or the corners of the lips can be pulled in, creating lip rounding.
- The **tongue** is somewhat deceptive in its size and shape. The parts that are obvious to an external observer are the **tip** (sometimes called the **apex**) and the **blade**. These are merely an appendage to the much larger tongue **body** (also called **dorsum**), a roundish muscular body that can move in all directions. Movements of the dorsum can radically change the shape of the vocal tract, a fact that is crucial in the production of distinct vowel sounds.
- The rear surface of the dorsum is called the **tongue root**. Behind it is a flap called the **epiglottis**.

### 1.3 Describing Speech Sounds

The human vocal tract can produce thousands of audibly distinct sounds. Of these, only a subset are actually used in human languages. Moreover, of this subset, some

<sup>2</sup> If you can produce a distinction between nasal and oral vowels, as in French or Portuguese, then it is possible to watch the velum work, using a flashlight and a mirror. When a speaker alternates between oral and nasal vowels, the velum is seen to billow up and down like a sail (which is what “velum” literally means in Latin).

sounds are much more common than others. For example, almost every language has a *t*-like sound, whereas very few languages have an epiglottal stop or a bilabial trill. Any one language uses only a fairly small inventory of distinct speech sounds, usually no more than a few dozen.

The commonsense distinction of **vowels** and **consonants** is a generally valid one for phonetics and phonology. Roughly, vowels are highly sonorous sounds, made with a relatively open vocal tract. Consonants involve some kind of constriction (or more than one constriction) in the vocal tract. They are quieter than vowels, and often are detectable by the ear not so much by their own sound as by the transitional acoustic events that occur at the boundaries of consonants and vowels.

For both vowels and consonants, phonetic description involves assigning a **phonetic symbol** to each sound. This book will use the standard, internationally accepted phonetic symbol set called the International Phonetic Alphabet (IPA), promulgated by the International Phonetic Association.

It should be clear why the use of standard symbols, rather than spelling, is crucial. The spelling systems of most languages are ambiguous (consider *read*, *bow*) and inconsistent in the depiction of identical sounds (consider *whole/hole*, *reall/reel*). Cross-linguistically, the situation is even worse, as different languages employ the same letters to depict different sounds: the letter *j* spells four quite different sounds in English, French, Spanish, and German (in IPA these are [dʒ], [ʒ], [x], and [j]). Since this book will be presenting data from many languages, I will standardize all data using IPA transcription.

Phonetic transcription is traditionally given surrounded by square brackets. Thus, one possible rendition of the previous sentence in IPA (as pronounced in my own dialect of English) is:

[fə'neɪk ɪs'ɪæ'n'skɪpʃən ɪz ɪs'ɪæ'dɪʃənəlɪ 'ɡɪvən sə'ɪæʊndɪd baɪ 'skweɪ 'brækɪts]

## 1.4 Consonants

Consonants are classified along three dimensions: **voicing**, **place of articulation**, and **manner of articulation**.

### 1.4.1 Voicing

In a voiced consonant, the vocal cords vibrate. For example, the “s” sound, for which the IPA symbol is simply [s], is voiceless, whereas the “z” sound (IPA [z]) is voiced. If you say “sa, za” while planting the palm of your hand firmly on the top of your head, you should feel the vibrations for [z] but not for [s].

The sounds [p t k] are voiceless. The sounds [b d g] as they occur in (for example) French or Japanese are voiced; in English they are often voiced for only part of their duration or even not at all; nevertheless the symbols [b d g] are traditionally used for them.

### 1.4.2 Manner

There are various manners of articulation.

In a **stop**, the airflow through the mouth is momentarily closed off. This can be done by the two lips, forming [p] or [b]; by the tongue tip touching the alveolar ridge, forming [t] or [d]; by the tongue body touching the palate, forming [k] or [g]; and in other ways.

In a **fricative**, a tight constriction is made, so that air passing through the constriction flows turbulently, making a hissing noise. Some of the fricatives of English are [f], [v], [θ] (the first sound of *thin*), and [ð] (the first sound of *the*). In **sibilant** fricatives, the mechanism of production is more complex: a stream of air is directed at the upper teeth, creating noisy turbulent flow. The four sibilant fricatives of English are [s], [z], [ʃ] (the first sound of *shin*), and [ʒ] (the consonant spelled *s* in *pleasure*).

An **affricate** is a stop followed by a fricative, made at the same location in the mouth in rapid succession so that the result has the typical duration of a single speech sound. English has two affricates: voiceless [tʃ] (as in *church*) and voiced [dʒ] (as in *judge*). As can be seen, the IPA symbol for an affricate is made with the symbols for the appropriate stop and fricative, optionally joined with a ligature.

Affricates are often considered to be a species of stop; that is, “affricated stops.”

In a **nasal** consonant, the velum is lowered, allowing air to escape through the nose. Most nasal consonants have a complete blockage within the mouth at the same time. The places of articulation for nasals are mostly the same as those for stops. The nasal consonants of English are [m] (*mime*), [n] (*none*), and [ŋ] (*young*).

Nasals like [m, n, ŋ] in a certain sense are also stops, since they involve complete closure in the mouth; hence the term “stop” is ambiguous. I will use this term here in its strict sense, which includes oral stops only.

In **taps** and **flaps**, an articulator makes a rapid brush against some articulatory surface. The motion of the articulator is forward in a flap, backward in a tap. North American varieties of English have alveolar taps (IPA [ɾ]) in words like *lighter* and *rider*.

In a **trill**, an articulator is made to vibrate by placing it near an articulatory surface and letting air flow through the gap. Many dialects of Spanish have an alveolar trill (IPA [r]) in words like *perro* ‘dog’. The uvula ([ʀ]) and lips ([β]) can also be trilled.

**Approximants** are consonants in which the constriction is fairly wide, so that air passes through without creating turbulence or trilling. In **lateral approximants**,



the air passes around the sides of the tongue, as in English [l]. In **central approximants**, the flow is through a gap in the center. English dialects have (at least) three central approximants, namely [j],<sup>3</sup> as in *youth*, [w], as in *win*, and [ɹ], as in *ray*.

The last three categories just given are sometimes presented with a different classification. The **liquids** are the sounds that have the characteristic acoustic quality of *l*-like and *r*-like sounds.<sup>4</sup> This term groups [l] and similar sounds together with tap [ɾ], trilled [r], approximant [ɹ], and various similar “r” sounds. Under this same scheme, the **glides** (also called **semivowels**) are the central approximants; that is, [j], [w], and similar sounds covered below.

### 1.4.3 Place of articulation

I will cover most of the possible places of articulation, proceeding from front to back. Each place is shown in figure 1.4: dotted lines indicate the approximate path taken by an articulator in making contact with the opposite wall of the vocal tract.

- **Bilabial** sounds are made by touching the upper and lower lips together. English has a voiceless bilabial stop [p], a voiced bilabial stop [b], and a (voiced) bilabial nasal [m].

Note that the description just given follows the standard form for describing a consonant: **voicing**, then **place**, then **manner**. In the case of nasals and approximants, which are normally voiced, it is common to specify only place and manner.

- **Labiodental** sounds are made by touching the lower lip to the upper teeth. English has a voiceless labiodental fricative [f] and a voiced one, [v].
- **Dental** sounds are made by touching the tongue to the upper teeth. This can be done in a number of ways. If the tongue is stuck out beyond the teeth, the sound is called an **interdental**, though we will not be concerned with so fine a distinction. English has a voiceless dental fricative [θ] (*thin*) and a voiced one [ð] (*the*).
- **Alveolar** sounds are made by touching the tip or blade of the tongue to a location just forward of the alveolar ridge. English has a voiceless alveolar stop [t], a voiced alveolar stop [d], voiceless and voiced alveolar fricatives [s] and

<sup>3</sup> The IPA symbol is modeled after the spelling of German, Dutch, Polish, Swedish, and various other languages. The letter *y*, used in English, has a different meaning in IPA, given below.

<sup>4</sup> In terms of speech acoustics, *l*-like sounds have an exceptionally high third **formant** (band of acoustic energy), and *r*-like sounds have an exceptionally low third formant. Non-liquid approximants have third formants that would be expected, given their first and second formants.

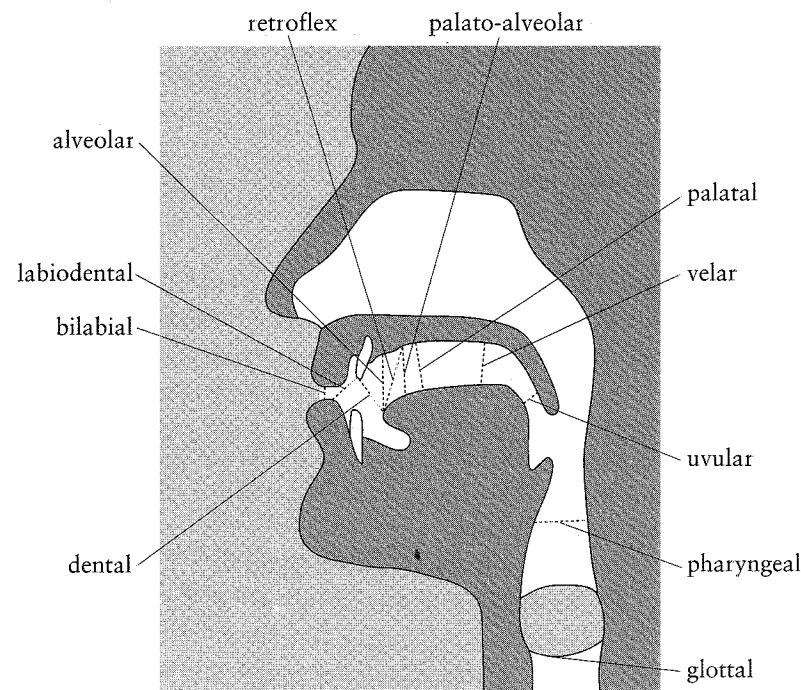


Figure 1.4 Place of articulation

[z] (both of them sibilants), a voiced alveolar nasal [n], a voiced alveolar lateral approximant [l],<sup>5</sup> and a voiced alveolar central approximant [ɹ].

- **Palato-alveolar** sounds (sometimes called **post-alveolar**) are made by touching the blade of the tongue to a location just behind the alveolar ridge. English has a voiceless palato-alveolar fricative [ʃ] (*shoe*), a voiced palato-alveolar fricative [ʒ] (*vision*), a voiceless palato-alveolar affricate [tʃ] (*church*), and a voiced palato-alveolar affricate [dʒ] (*judge*).
- **Retroflex** sounds are made by curling the tongue tip backward, and touching the area just behind the alveolar ridge. Some English speakers lack the alveolar approximant [ɹ] and instead have a retroflex one, transcribed [ɻ]; retroflex stops and affricates are common in languages of India and Australia.

In the strict sense of the term, palato-alveolars and retroflexes have the same place of articulation: the same place on the roof of the mouth is contacted.

<sup>5</sup> For many speakers of English, the “l” sound is actually dental [ɭ].

They differ in the part of the tongue (blade or tip) that makes the contact. Conventionally, however, palato-alveolar and retroflex are referred to as separate places of articulation.

- **Palatal** sounds are made by touching the tongue blade and the forward part of the tongue body to the hard palate. [j] (*young*) is sometimes described as a palatal approximant (see §1.5.5 below for a different kind of description); various languages have a variety of other manners of articulation at the palatal place.
- **Velar** sounds are made by touching the body of the tongue to the hard or soft palate. English has three velar sounds: a voiceless velar stop [k], a voiced velar stop [g], and a velar nasal [ŋ] (*sing*).
- **Uvular** sounds are made by moving the tongue body straight back to touch the uvula and neighboring portions of the soft palate. The “r” sound of French and German is usually a voiced uvular fricative, [ʁ]. The nasal consonant that occurs at the end of many words in Japanese, transcribed here with [ŋ], is pronounced by many speakers as uvular [ɴ].
- **Pharyngeal** sounds are made by moving the tongue body down and back into the pharynx. A voiceless pharyngeal fricative is transcribed [ħ]; it occurs for example in Arabic.
- **Glottal** sounds are made by moving the vocal cords close to one another. English has a voiceless glottal fricative [h].

#### 1.4.4 Consonant chart

Table 1.1 reproduces the part of the official IPA chart covering consonants.

It can be seen that any consonant in the chart is describable with the terminology given in table 1.1, and that a fair number of sounds are listed that do not occur in English. Quite a few of these will come up in the chapters to follow.

The symbols for dentals, alveolars, and palato-alveolars are systematically ambiguous. Where it is important to make a distinction, it is possible to do so with diacritics:

[t̪] = voiceless dental stop

[t̺] = voiceless alveolar stop

[t̺̪] = voiceless palato-alveolar (= post-alveolar) stop

Affricates are formed by joining a stop and fricative symbol together, as in for instance [tʃ], the first and last sound of *church*. The same ligature may be used for so-called “complex segments” such as labial-velar [kp], which are formed at two places of articulation simultaneously.

A subsidiary part of the IPA chart (table 1.2) covers consonants in which the airflow comes not from the lungs, but from motions of the larynx (**implosives**, with inward airflow, and **ejectives**, with outward), or of the tongue body (**clicks**).

Table 1.3 shows consonants that don’t fit into the main IPA chart.

Table 1.1 The main portion of the IPA consonant chart.  
www.arts.gla.ac.uk/IPA/IPA\_chart\_(c)2005.pdf

	Bilabial	Labiodental	Dental	Alveolar	Post-alveolar [= palatoalveolar]	Retroflex	Palatal	Velar	Uvular	Pharyngeal	Glottal
Plosive [= stop]	p b			t d		t ɖ	c ɟ	k ɡ	q ɢ		ʔ
Nasal	m	ɱ		n		ɳ	ɲ	ŋ	ɴ		
Trill	ʙ			r					ʀ		
Tap or Flap		ɹ		ɾ		ɽ					
Fricative	ɸ β	f v	θ ð	s z	ʃ ʒ	ʂ ʐ	ç ʝ	x ɣ	χ ʁ	ħ ʕ	h ɦ
Lateral fricative				ɬ ɮ							
[Central] approximant		ʋ		ɹ		ɻ	j	ɰ			
Lateral approximant				l		ɭ	ʎ	ʟ			

Where symbols appear in pairs, the one to the right represents a voiced consonant. Shaded areas denote articulations judged impossible.

**Table 1.2** The IPA chart: non-pulmonic consonants.  
www.arts.gla.ac.uk/IPA/IPA\_chart\_(c)2005.pdf

Clicks	Voiced implosives	Ejectives
◌ ɓ Bilabial	ɓ Bilabial	ʼ as in
◌ ǀ Dental	ɗ Dental/alveolar	pʼ Bilabial
◌ ǃ (Post)alveolar	ɟ Palatal	tʼ Dental/alveolar
◌ ɥ Palatoalveolar	ɡ Velar	kʼ Velar
◌ ǁ Alveolar lateral	ɠ Uvular	sʼ Alveolar fricative

**Table 1.3** The IPA chart: other consonants.  
www.arts.gla.ac.uk/IPA/IPA\_chart\_(c)2005.pdf

ɱ	Voiceless labial-velar fricative
w	Voiced labial-velar approximant
ɥ	Voiced labial-palatal approximant
ħ	Voiceless epiglottal fricative <sup>a</sup>
ʕ	Voiced epiglottal fricative
ʡ	Epiglottal plosive
ç ʝ	Alveolo-palatal fricatives
ɺ	Alveolar lateral flap
ɸ	Simultaneous f and x

*Note:* <sup>a</sup> Epiglottals are made by touching the upper edge of the epiglottis (see figure 1.3) to the rear wall of the pharynx.

## 1.5 Vowels

Vowels differ from consonants in that they do not have “places of articulation,” that is, points of major constriction in the vocal tract. Rather, the vocal tract as a whole acts as a resonating chamber. Modifying the shape of this chamber using movements of the tongue, jaw, and lips causes different timbres to be imparted to the basic sound produced at the vocal cords.

There are three basic modifications that one can make to the shape of the vocal tract. Vowels are described by specifying each modification used.

### 1.5.1 Rounding

An obvious modification one can make to the shape of the vocal tract is to round the lips, thus narrowing the passage at the exit. This happens, for example, in

the vowels that many English dialects have for *boot* [u], *book* [ʊ], and *boat* [o]. These are called **rounded** or simply **round** vowels. Other vowels, such as the [i] of *beet* or the [ʌ] of *cut*, are called **unrounded**.

### 1.5.2 Height

Another modification one can make to the shape of the vocal tract is to make the passage through the mouth wider or narrower. Widening is accomplished by opening the jaw and/or lowering the body of the tongue towards the bottom of the mouth. Narrowing is accomplished by raising the jaw and/or raising the body of the tongue.

The terminology for describing these changes is based on the height of the tongue body, without regard to whether this is due to jaw movement or tongue movement. Vowels are classified as **high**, **mid**, or **low**. In effect, high vowels have a narrow passage for the air to pass through, and low vowels have a wide passage. Another terminology, which appears on the IPA chart, is to call the high vowels **close** and the low vowels **open**.

Examples of high vowels in English are [i], the vowel of *beat*, and [u], the vowel of *boot* (for some English speakers; see below). Examples of low vowels are [a], the vowel of *spa*, and [æ], the vowel of *bat*. You can feel the oral passage widening and narrowing if you pronounce a sequence of vowels that alternates between high and low, such as [i æ i æ i æ i æ].

### 1.5.3 Backness

The third primary way of changing the vocal tract shape is to place the body of the tongue towards the front part of the mouth or towards the back. Vowels so made are called **front** and **back** vowels, respectively; and vowels that are neither front nor back are called **central**. For example, [i] (*beat*) is a high front unrounded vowel, and the [u] vowel that appears in many languages (e.g. Spanish, French, and Persian) is a high back rounded vowel: French [ʁuʒ] ‘red’.

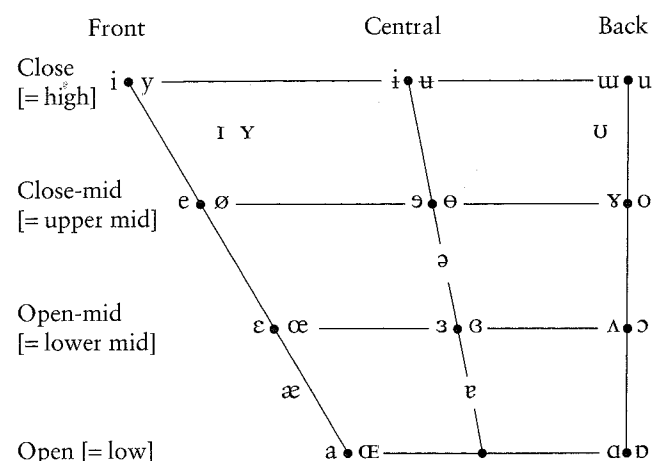
[u] is often described as being the vowel of English words like *boot*. This is true, but only for certain dialects of English; other dialects have a vowel that is closer to central than back: [bʊt].

A way to feel backness, particularly if you know how to say a true [u] instead of [ʊ], is to say the sequence [i u i u i u i u . . .] and feel your tongue body sliding forward and backward along the roof of your mouth.

### 1.5.4 Describing vowels systematically

We now have three dimensions for classifying vowels, each based on a particular modification of the vocal tract shape: rounding, height, and backness. The three dimensions allow us to describe vowels clearly and to organize them in a chart.

The IPA chart for vowels is shown in figure 1.5:



Where symbols appear in pairs, the one to the right represents a rounded vowel.

Figure 1.5 The IPA chart for vowels.

[www.arts.gla.ac.uk/IPA/IPA\\_chart\\_\(c\)2005.pdf](http://www.arts.gla.ac.uk/IPA/IPA_chart_(c)2005.pdf)

For the use of these symbols in depicting the vowels of English, see p. 21.

An awkward problem with the IPA is that there is no symbol for the low central unrounded vowel, which appears to be the most common of all vowels in the world's languages. Below, I will follow the practice of many other linguists in adapting the symbol [a], which strictly speaking designates a front vowel in IPA, to denote the central vowel; where it is crucial, I will state which vowel is being described.

The IPA chart is also a bit puzzling for offering vowel symbols that have no description in terms of categories; for instance [ɪ] floats in the upper left part of the chart without any row or column label. We will remedy this below when we set up a system of **features** (chapter 4) to classify vowels; see p. 82.

### 1.5.5 Glide-vowel correspondences

Glides can be described in two ways, because they are essentially the non-syllabic equivalents of vowels (semivowels). Thus, [j] is in IPA terms a palatal central approximant, but it is also describable as a high front unrounded glide, and is thus the consonant counterpart of [i]. Likewise, [w] is a labial-velar central approximant, but it is also treatable as a high back rounded glide, the counterpart of [u].

### 1.5.6 Diphthongs

A **diphthong** (note the spelling) is a sequence of two vowels that functions as a single sound. Further, a diphthong always forms just one syllable, whereas a

two-vowel sequence forms two. You can transcribe a diphthong by stringing together two vowel symbols denoting its beginning and end, and optionally connecting them with a ligature.

English has numerous diphthongs, the number depending on dialect. The three most noticeable ones are [aɪ], which appears in *ride*; [ɔɪ], which appears in *boy*; and [aʊ], which appears in *how*. (The diphthong [aʊ] is pronounced [æʊ] by many speakers.) In addition, most dialects have diphthongs in which the difference between the two component vowels is more subtle, and a rough transcription can use a monophthong symbol. Thus, the sound of *bay*, which some sources transcribe as [e], is [eɪ] for most English speakers, and [o] (*go*) is most often [oʊ]. Other vowels of English can be more or less subtly diphthongal; for example, [ɛə] for what is normally transcribed [ɛ] (as in *bed*).

### 1.5.7 Syllabic consonants

It is possible for sounds that are normally consonants to be prolonged slightly and serve as the nucleus of a syllable. Such sounds are called **syllabic consonants**; they are transcribed by placing the IPA syllabic marker under them, as in [ŋ̩] (*button*, IPA ['bʌtɪŋ̩]). Generally, only the more sonorous consonants, such as liquids or nasals, can occur as syllabic.<sup>6</sup> Syllabic glides are simply vowels, as noted above in §1.5.5.

## 1.6 Stress and Tone

Many languages make distinctions of stress; roughly, the degree of loudness or effort with which a syllable is pronounced. IPA provides the symbol ['] to indicate a strong stress, and [ˌ] to indicate a relatively weak (secondary) stress. These marks are placed just before the *syllable*, not the vowel, thus ['ræbɪt] *rabbit*, [ə'baʊt] *about*.

A great many of the world's languages are **tone** languages, using differences of pitch to distinguish words from one another. The IPA offers two distinct systems of tonal transcription. In table 1.4, the symbols given first in each category are ordinarily used for languages with mostly level tones; the ones given second are for languages in which the tones often glide up or down within a syllable.

**Intonation** is use of the voice for linguistic purposes other than distinguishing words; for instance, for distinguish questions from statements. The IPA intonation marks will not suffice for our purposes (see chapter 15), and are omitted from table 1.4.

<sup>6</sup> Various Berber languages have syllabic fricatives and stops.

Table 1.4 The IPA chart: suprasegmentals.  
www.arts.gla.ac.uk/IPA/IPA\_chart\_(c)2005.pdf

The two example words in this chart are *phonetician* and *react*.

TONES AND WORDS ACCENTS					
' Primary stress	ˈfəʊnəˈtɪʃən	LEVEL		CONTOUR	
, Secondary stress		ẽ or ˊ	extra high	ẽ or ˋ	rising
: Long	eː	é	high	ê	falling
˙ Half-long	e˙	ē	mid	ẽ	high rising
˘ Extra-short	ẽ	è	low	ẽ	low rising
. Syllable break	ri.ækt	ẽ	extra low	ẽ	rising-falling etc.

## 1.7 Diacritics

The IPA provides a number of diacritics that may be attached to symbols to modify their meaning. Of these, the most important ones used here are as follows:

- [ʰ], for **aspiration**. In [pʰ, tʰ, kʰ], aspiration is a puff of breath (which in English can be felt with the fingers, placed in front of the mouth), with a delay in the onset of voicing in a following vowel.
- [̥], used to denote **voicelessness** in a symbol that is otherwise interpreted as voiced. For example, [i̥] is a voiceless vowel, found for instance in Japanese.
- [ʳ], the **rhoticity** diacritic, meaning that the tongue tip or blade is curled backward. Rhotacized schwa, [əʳ], is a common way of transcribing the syllabic consonant [ɹ]. (Note that this is essentially parallel to the vowel–glide correspondences described in §1.5.7 above. [əʳ] and [ɹ], are essentially the same sound, described from the viewpoint of vowels and consonants.)
- [ː] is placed after vowels (and occasionally consonants<sup>7</sup>) to show they are **long**; likewise [ˑ] is placed over a speech sound to show that it is **extra short**.
- [̃], a tilde placed over a symbol, indicates that it is **nasalized**; that is, pronounced with the velum lowered as in French [mẽ] ‘hand’.
- **Tiny adjustments for vowel quality**: [̟] a bit higher, [̠] a bit lower, [̠̞] a bit backer, [̡̞] a bit fronter. The backer/fronter diacritics may also be used for place of articulation in consonants.

<sup>7</sup> For consonants, probably the more common practice is to indicate length by doubling.

## 1.8 Phonetic Transcription

The accurate rendering of pronunciation using phonetic symbols is a skill learned through practice; see Exercises below. Here I will note only that different transcriptions are appropriate for different purposes.

- On occasion, issues of phonological importance will hinge on matters of tiny phonetic detail. Here, the wide range of diacritics offered by the IPA can be very useful. Transcription that attempts to use symbols to represent speech as accurately as possible is called **narrow** transcription.
- Otherwise, a so-called **broad** transcription, abstracting away from non-crucial detail, usually suffices. Often, transcription is narrow in one part of a word (the part containing the matter of interest), but broad elsewhere.
- In selecting a broad transcription, sometimes it is useful to idealize across speakers somewhat. Thus, the various English dialects have a remarkable range of phonetic qualities for the vowel of the word *out* ([aʊ], [æʊ], [ɑʊ], [ɑ̃], [ɛʊ], [ʌʊ], etc.), but if one's focus is on other matters, it is harmless to use [aʊ], which is fairly standard in reference sources. The advantage is that the experienced reader can read a standardized transcription more quickly.

## Exercises

### 1 Web exercises

Phonetic exercises usually involve production or perception, so they are best done on line where sound files can be provided. The exercises for Peter Ladefoged's textbook (see Further reading, below) are posted at [www.phonetics.ucla.edu](http://www.phonetics.ucla.edu). Some exercises used in the author's own phonetics teaching are available at:

[www.linguistics.ucla.edu/people/hayes/103/EnglishTranscriptionPractice/](http://www.linguistics.ucla.edu/people/hayes/103/EnglishTranscriptionPractice/)  
[www.linguistics.ucla.edu/people/hayes/103/Allophones/](http://www.linguistics.ucla.edu/people/hayes/103/Allophones/)  
[www.linguistics.ucla.edu/people/hayes/103/CTranscriptionPractice/](http://www.linguistics.ucla.edu/people/hayes/103/CTranscriptionPractice/)

### 2 Study guide questions for this chapter

- The IPA consonant chart (p. 11) includes a shaded cell for pharyngeal nasals, claiming that such a sound is “judged impossible.” Why is this so? Explain your answer.

- b. Same question as (a), but for the voiced counterpart of the glottal stop.
- c. Find a pair of contrasting examples showing that we need to be able to transcribe [tʃ] distinct from [tʃ̥]. Give IPA transcriptions for your examples. (Hint: try stringing words together.)
- d. Construct an unambiguous IPA symbol to depict a voiceless dental sibilant affricate, explaining each diacritic that you use.
- e. Would it be sensible to use [ɔ̥] in an IPA transcription? Explain your answer.
- f. In articulating a velar nasal, the tongue body need not move as far to achieve closure as in a velar stop. Explain why, referring to figure 1.3.
- g. Give three ways to use the IPA diacritics to transcribe a low central unrounded vowel.
- h. Find the errors in the following IPA transcriptions and correct them: *sing* [sɪŋ], *threat* [θræt], *table* ['tēɪbl̩], *exit* ['exɪt], *ballad* [b'æləd], *heraldry* ['hɛrəldrɪ], *easy* [ɪzi], *music* ['musɪk].

### Further reading

Some important resources for the International Phonetic Alphabet are:

- The *Handbook of the International Phonetic Association: A Guide to the Use of the International Phonetic Alphabet* (1999, Cambridge University Press).
- A website containing sound files for all the examples given in the Handbook: <http://web.uvic.ca/ling/resources/ipa/handbook.htm>.
- The official IPA website (<http://www2.arts.gla.ac.uk/IPA/ipa.html>).
- The widely used free IPA fonts distributed by the Summer Institute of Linguistics ([http://scripts.sil.org/cms/scripts/page.php?site\\_id=nrsi&id=IPAhome](http://scripts.sil.org/cms/scripts/page.php?site_id=nrsi&id=IPAhome)).

An introductory phonetics textbook that I rely on in my own phonetics teaching is *A Course in Phonetics*, by Peter Ladefoged (5th ed., 2005, Heinle). This text is accompanied by downloadable sound files: see [www.phonetics.ucla.edu](http://www.phonetics.ucla.edu). A wide-ranging study of speech sounds is in Peter Ladefoged and Ian Maddieson, *The Sounds of the World's Languages* (1996, Blackwell).

The student who examines journal articles and other reference sources in phonology will encounter, in addition to IPA, a bewildering variety of other phonetic symbols. One also often finds the same symbol used in radically different ways. A useful resource for navigating this thicket is the *Phonetic Symbol Guide*, by Geoffrey Pullum and William Ladusaw (2nd ed., 1996, University of Chicago Press).

A useful webpage on vocal tract anatomy is [www.phon.ox.ac.uk/~jcoleman/phonation.htm](http://www.phon.ox.ac.uk/~jcoleman/phonation.htm).

## 2 Phonemic Analysis

### 2.1 Phonology and Phonetics

As noted in the previous chapter, there are two branches of linguistics that deal with speech sounds. Phonetics studies speech sounds in ways that are close to the speech stream, focusing on production, acoustics, and perception. Phonology tends to be more abstract, dealing not directly with the physical nature of speech sounds (though that is of course quite relevant), but rather with the largely unconscious **rules** for sound patterning that are found in the mind/brain of a person who speaks a particular language. It could be said that a phonologist is a kind of grammarian, and the area of grammar that she studies is the sound pattern of a language.

The rules studied by phonologists come in various kinds. First, phonetic study shows that sounds *vary with their context*, often in complex ways; and phonologists hypothesize rules to characterize this variation. Second, the *sequencing and distribution* of speech sounds is not arbitrary, but follows patterns also describable with rules. Third, phonology is *interfaced* with other components of the grammar, particularly morphology and syntax, and there are rules that characterize the way in which sound patterning reflects information that arises within these components.

The phonologies of many languages often show a level of complexity that make them a worthwhile intellectual challenge for the phonologist trying to understand them. It can take many years of careful research to fully explicate the sound pattern of a language. What is remarkable is that the same pattern is learned quite rapidly, at the intuitive level, by humans when they are exposed to it in childhood.

### 2.2 Distinctiveness and Contrast

The sounds of a language are intrinsically meaningless: their only purpose is to form the building blocks of which words are made. For example, because English has the sounds [t] and [d], the possibility exists of English having the word