SSC: The Science of Talking

(for year 1 students of medicine)

Week 3:

Sounds of the World's Languages (vowels and consonants)

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See also: Abercrombie, David (1909–1992); Bloomfield, Leonard (1887–1949); Chomsky, Noam (b. 1928); Distinctive Features; Firth, John Rupert (1890–1960); Generative Semantics; Jones, Daniel (1881–1967); Phoneme; Phonology: Overview; Pike, Kenneth Lee (1912–2000); Saussure, Ferdinand (-Mongin) de (1857–1913); Sound Change; Speech Synthesis; Spelling Reform Proposals: English; Sweet, Henry (1845–1912); Trubetskoy, Nikolai Sergeievich, Prince (1890–1938).

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Phonetic Classification

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Phonetic classification (or taxonomy) is the system of categories and descriptive labels that underlies the International Phonetic Alphabet and the unaided (impressionistic) analysis and transcription of speech by trained observers. It depends upon regarding speech as a succession of sounds (segments) and attempts to characterize the production of each such segment, often (though not exclusively) by specifying a relatively static target configuration.

Airflow and Voice

The basis of all normal speech is a controlled outflow of air from the lungs, termed the 'egressive pulmonic airstream.' Passing up the trachea, air flows through the larynx, a cartilaginous structure containing the vocal folds ('vocal cords' in older terminology). They are attached close together at the front, but are moveable at the rear by the arytenoid cartilages, thus forming an adjustable valve. For ordinary soundless breathing, the folds are held apart (abducted) at their rear ends and form a triangular opening known as the 'glottis.' In another adjustment, the arytenoids can be brought together (adducted), and the folds pressed into contact along their length. This closes the glottis and prevents the flow of air. In a third possibility, the folds can be gently adducted so that air under pressure from the lungs can cause the folds to vibrate as it escapes between them in a regular series of pulses. The open glottis position gives rise to speech sounds (generally consonants) said to be 'voiceless,' such as those symbolized as [s] or [f]; the closed position (if maintained briefly in the course of speech) corresponds to the so-called 'glottal stop,' symbolized as [ʔ] while the vibrating adjustment gives 'voiced' sounds, which include the majority of all ordinary vowels and numerous consonants. Many consonants are found in voiced–voiceless pairs; for example, [z] is the voiced counterpart of [s], and [v] is the voiced counterpart of [f].

Voice can not only be switched on and off, but also controlled in loudness, pitch, and quality. Controlled variations in pitch give rise to tone and intonation distinctions. Voice 'quality' refers to the mode of vibration of the vocal folds and its audible effects. Normal (modal) voice produces a clear, regular tone and is the default in all languages. In 'breathy' voice (also called 'murmur'), vibration is accompanied by audible breath noise. In English, such an adjustment has only paralinguistic value, but in other languages, brief interludes of breathy voice assist in marking linguistic contrasts and may be analyzed as properties of particular segments. Other glottal adjustments include narrowing without vibration, which produces 'whisper.' The generation of sound in the larynx is termed 'phonation.'

The Supraglottal Tract

Having passed through the larynx, air enters the supraglottal tract, which is usually visualized at its central (midsagittal) plane, as seen in a lateral X-ray (see Figure 1).

The lowest part of the supraglottal tract is the 'pharynx,' which is bounded at the front by the 'epiglottis' and the 'root' of the tongue. At the top of the pharynx, the vocal tract branches into the oral and nasal cavities. The entrance to the nasal cavity is

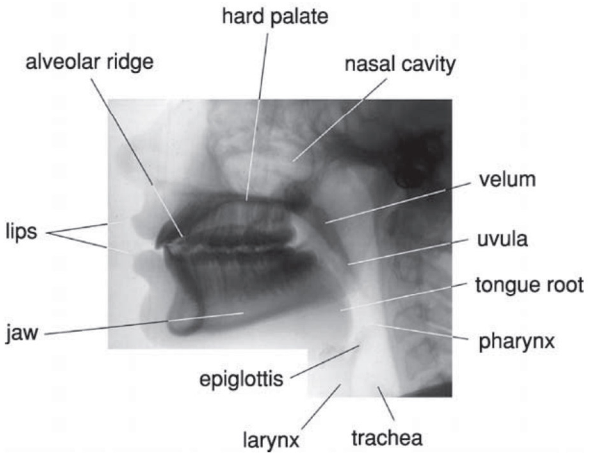


Figure 1 An X-ray image of the vocal tract at rest. The subject is an adolescent female. The velum is shown in the open position.

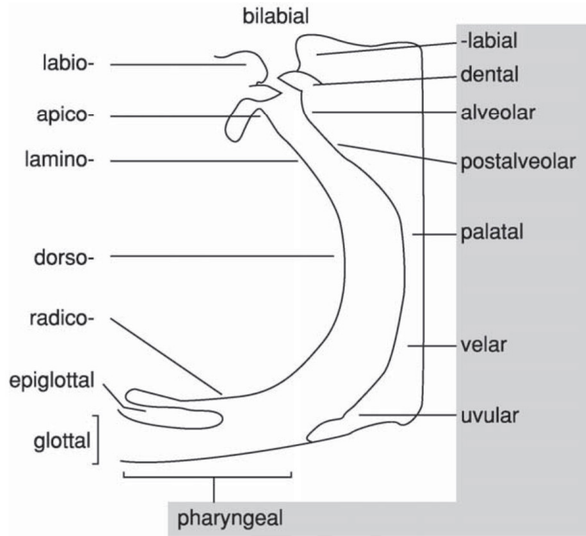


Figure 2 Terminology for place of articulation. The vocal-tract outline is rotated through 90 degrees to make the text clearer.

controlled by the 'velum' (or soft palate), which operates like a further valve. It can be raised, forming a 'velic' closure against the rear wall of the pharynx, thus preventing air from entering the nasal cavity, or lowered, allowing flow into the nasal cavity and thus out of the nostrils. Air flowing into the oral cavity can eventually leave via the lip orifice, though its path can be controlled or stopped by suitable maneuvers of the tongue and lips.

The upper surface of the oral cavity is formed by the 'hard palate,' which is continuous with the moveable soft palate. The palate is domed transversely as well as longitudinally and bordered by a ridge holding the teeth. In a midsagittal view, the portion of this behind the upper incisors is seen in section and is generally referred to as the 'alveolar ridge.' The lower surface of the oral cavity is dominated by the tongue, a large muscular organ that fills most of the mouth volume when at rest. Various parts of the tongue can be made to approach or touch the upper surface of the mouth, and complete airtight closures are possible at a range of locations, the closure being made not only on the midline where it is usually visualized, but extending across the width of the cavity and back along the tongue rims. At the exit from the mouth, the space between upper and lower teeth can be altered by adjusting the jaw opening, while the lips can independently assume a range of adjustments, again including complete closure.

Place and Manner of Articulation

Vowels are, in general terms, sounds produced with a relatively open vocal tract through which air flows with little resistance, while consonants involve some degree of obstruction to the airflow (often total blockage). 'Place of articulation' refers to the location along the vocal tract where a consonantal obstruction is formed.

Terminology for place is fairly uncontroversial. Common terms are shown in Figure 2, organized around the familiar midsagittal schematic of the vocal tract. Any word shown without a leading or trailing hyphen is a complete place term. Thus, 'palatal' refers to a type of articulation in which the front part of the body of the tongue approaches the hard palate, 'dental' refers to one made by the tip and/or blade of the tongue against the upper incisor teeth, and so on. A more precise terminology is obtained by taking hyphenated terms on the left, which denote 'active' articulators, and pairing them with terms from the shaded box that name 'passive' articulators. One of these combinations, 'labiodental,' is the only way of referring to the articulation so named. The terms 'post-' and 'pre-,' with the meanings 'back region of' and 'front region of,' are used when more precision is required in specifying a passive location. One of these, 'postalveolar,' is established on the IPA chart; 'postvelar' is in most contexts a synonym for 'uvular.' The so-called 'retroflex' place involves a backward displacement of the tongue tip towards some point along the palate, yielding apico-palatal articulation.

'Manner of articulation' refers to the type of obstruction used in the production of a consonant – whether, for example, the airflow is blocked completely for a brief time (yielding the manner known as 'plosive') or simply obstructed so that noisy turbulent flow occurs (the manner known as 'fricative').

Manners of articulation are summarized in **Table 1**. There is some variation in the order in which manners

THE INTERNATIONAL PHONETIC ALPHABET (revised to 1993, updated 1996)

CONSONANTS (PULMONIC)

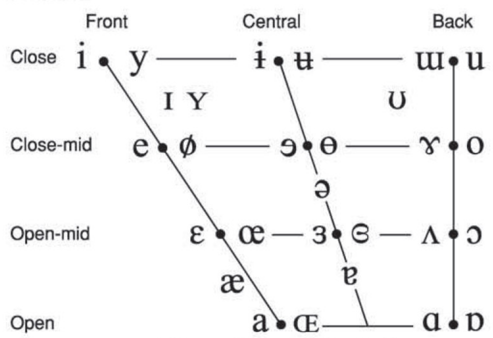
	Bilabial	Labiodental	Dental	Alveolar	Postalveolar	Retroflex	Palatal	Velar	Uvular	Pharyngeal	Glottal
Plosive	p b			t d		ʈ ɖ	c ɟ	k ɡ	q ɢ		ʔ
Nasal	m	ɱ		n		ɳ	ɲ	ŋ	ɴ		
Trill	ʙ			r					ʀ		
Tap or Flap				ɾ		ɽ					
Fricative	ɸ β	f v	θ ð	s z	ʃ ʒ	ʂ ʐ	ç ʝ	x ɣ	χ ʁ	ħ ʕ	h ɦ
Lateral fricative				ɬ ɮ							
Approximant		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

CONSONANTS (NON-PULMONIC)

Clicks		Voiced implosives		Ejectives	
ʘ	Bilabial	ɓ	Bilabial	ʼ	Examples:
ǀ	Dental	ɗ	Dental/alveolar	pʼ	Bilabial
ǃ	(Post)alveolar	ʄ	Palatal	tʼ	Dental/alveolar
ǂ	Palatoalveolar	ɠ	velar	kʼ	Velar
ǁ	Alveolar lateral	ʛ	Uvular	sʼ	Alveolar fricative

VOWELS



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

OTHER SYMBOLS

ʍ Voiceless labial-velar fricative

w Voiced labial-velar approximant

ɥ Voiced labial-palatal approximant

ʜ Voiceless epiglottal fricative

ʢ Voiced epiglottal fricative

ʡ Epiglottal plosive

ɕ ʑ Alveolo-palatal fricatives

ɺ Alveolar lateral flap

ɧ Simultaneous ʃ and x

Affricates and double articulations can be represented by two symbols joined by a tie bar if necessary. k͡p t͡s

SUPRASEGMENTALS

ˈ Primary stress

ˌ Secondary stress

ˌfoʊnəˈtɪʃən

ː Long eː

ˑ Half-long eˑ

˘ Extra-short ĕ

| Minor (foot) group

‖ Major (intonation) group

. Syllable break ɹi.ækt

‿ Lingking (absence of a break)

DIACRITICS Diacritics may be placed above a symbol with a descender, e.g. ŋ̊

̥ Voiceless	n̥ d̥	̤ Breathy voiced	b̤ a̤	̪ Dental	t̪ d̪
̬ Voiced	s̬ t̬	̰ Creaky voiced	b̰ a̰	̺ Apical	t̺ d̺
ʰ Aspirated	tʰ dʰ	̼ Linguolabial	t̼ d̼	̻ Laminal	t̻ d̻
̹ More rounded	ɔ̹	ʷ Labialized	tʷ dʷ	̃ Nasalized	ẽ
̜ Less rounded	ɔ̜	ʲ Palatalized	tʲ dʲ	ⁿ Nasal release	dⁿ
̟ Advanced	u̟	ˠ Velarized	tˠ dˠ	ˡ Lateral release	dˡ
̠ Retracted	e̠	ˤ Pharyngealized	tˤ dˤ	̚ No audible release	d̚
̈ Centralized	ë	̴ Velarized or pharyngealized	ɫ		
̽ Mid-centralized	e̽	̝ Raised	e̝ (ɹ̝ = voiced alveolar fricative)		
̩ Syllabic	n̩	̞ Lowered	e̞ (β̞ = voiced bilabial approxiamant)		
̯ Non-syllabic	e̯	̘ Advanced Tongue Root	e̘		
˞ Rhoticity	ɚ a˞	̙ Retracted Tongue Root	e̙		

TONES AND WORD ACCENTS

LEVEL			CONTOUR		
e̋ or	˥	Extra high	ě or	˩˥	Rising
é	˦	High	ê	˥˩	Falling
ē	˧	Mid	e᷄	˦˥	High rising
è	˨	Low	e᷅	˩˨	Low rising
ȅ	˩	Extra low	e᷈	˧˦˧	Rising-falling
↓		Downstep	↗		Global rise
↑		Upstep	↘		Global fall

Figure 3 The Intrernational Phonetic Alphabet.

Table 1 Summary of manners of articulation

Manner	*Definition*	*Sonorant*	*Comments*
Nasal	Complete oral closure, soft palate lowered to allow air to escape nasally	+	
Plosive	Complete closure, soft palate closed	−	
Affricate	Plosive released into fricative at the same place of articulation	−	Not always treated as a separate manner
Fricative	Close approximation of articulators, turbulent airflow	−	Sibilants, having wake-turbulence at the teeth, are an important sub-category
Lateral fricative	Complete closure on mid-line, turbulent flow at the side	−	
Lateral approximant	Complete closure on the mid-line, open approximation at the side	+	
Approximant	Open approximation, flow not turbulent	+	Approximants which are within the vowel space are also called semivowels
Trill	Flexible articulator vibrates in the airstream	+	In trills and taps the brief closures do not raise intra-oral air pressure significantly
Tap/flap	A single brief closure made by the tongue hitting the alveolar ridge	+	Flaps start with the tongue retroflexed

are listed by different authorities. This illustrates the fact that, unlike place, manner is not a single dimension. It is true that there is one main dimension, corresponding to degree of constriction, but manner also incorporates the 'nasal/oral' distinction (is the velum open as in [m] or [n], permitting flow via the nose?) and the 'central/lateral' distinction (is airflow along the midline of the tract as in most sounds, or is it temporarily diverted to the side(s), as in lateral sounds such as [l]?). The 'rate' of an articulatory manoeuvre is also relevant to manner. For instance, if the tongue tip and blade make one brief flick, sealing against the alveolar ridge, the resulting sound is called a 'tap,' symbolized as [ɾ] but the same closure made at a slower rate will be a plosive [d].

The IPA Chart

The fundamental insight in the traditional classification of consonants is the realization that voicing, place, and manner are orthogonal. A sound may be voiceless or voiced, and it may use any pitch or phonation type, regardless of its place or manner of production. In a similar way, places and manners may be (with certain restrictions) freely combined. This leads naturally to the presentation of combinatorial possibilities in the form of an array, with the columns representing places of articulation arranged in order from the lips to the glottis, and the rows being manners, essentially in order of increasing openness. The voiceless–voiced distinction is represented by putting an ordered pair of symbols in each cell. Not every cell of the array formed by the intersection of place and manner categories is populated. A distinction is drawn between sound-types that are humanly possible though not attested in known languages (such as voiceless palatal lateral fricative) and those that are physically impossible, such as voiced pharyngeal nasal (impossible because a pharyngeal closure, even supposing it can be achieved, is upstream from the velum). Blank cells on the IPA chart relate to the possible-but-unattested type, shaded cells relate to impossible combinations. In some cells, such as those for nasals, there is only one symbol, corresponding to a voiced sound. The voiceless counterparts are certainly possible, and are indeed encountered in languages, but are sufficiently uncommon that a representation using an additional 'voiceless' diacritic is not an inconvenience.

Vowel Classification

Vowels are all relatively open, but their distinct auditory qualities are clearly controlled by articulatory adjustments of some sort. In all, the tongue body is arched within the oral cavity. In a vowel such as [i], the tongue body is well forward in the mouth, beneath the hard palate, whereas in [u] it is pulled back. And whereas both [i] and [u] have the bunched tongue relatively high in the oral cavity, the vowel [a] requires it to be lowered well away from the palate (the jaw may open to assist). This gives rise to the concept of a two-dimensional vowel 'space' in the oral cavity, the dimensions being 'high-low' (also called 'close-open') and 'front-back,' within which the bunched tongue may be located. A third independent factor is lip posture. The lips may form a broad, 'spread' orifice, as in [i], or be 'rounded' and protruded into a small opening, as in [u]. Again, the power of this approach comes from realizing that the three properties that have been identified are orthogonal: any degree of height can be combined with any position on the front-back dimension, and any tongue-body position can be combined with lip-rounding or its absence. For example, keeping a tongue position for [i] but adding lip-rounding in place of lip-spreading yields a quality that the IPA symbolizes as [y] and that is essentially that which is heard in a French word such as *lune* [lyn] 'moon.' The vowels at the corners of the vowel space can be given reasonably precise articulatory definitions. For instance, the height (or closeness) of an extreme variety of [i] is limited by the requirement that the vowel shall be an open articulation without friction. Moving the tongue beyond the upper front border of the vowel space will result in a sustained (palatal) fricative consonant. In the 'Cardinal Vowel' system (a refinement of vowel classification developed by the celebrated British phonetician Daniel Jones and essentially incorporated into the IPA), not only are the corner vowels thus fixed, but additional auditory qualities at two intermediate heights, both front and back, are learned and imitated during phonetic training to provide further reference points. The vowel space, which in older literature was often represented as triangular, becomes a quadrilateral of standardized proportions, originating partly from X-ray studies of tongue position during sustained vowel production. The vowels of any language can be envisaged as points within this space (not necessarily on its periphery, of course) and symbolized appropriately. Vowels of changing quality (diphthongs such as that heard in English *mouth*) can be represented as a trajectory within the space.

Further Aspects of Vowel Classification

Many languages make use of contrastive 'nasalization' of vowels. Here, essentially identical configurations of tongue and lip adjustment are differentiated by producing one with a lowered velum, adding the acoustic resonances of the nasal cavity to give a distinct auditory effect. Thus, French [sɛ] *sait* '(he/she) knows' has a nonnasalized (oral) vowel, while [sɛ̃] *saint* 'saint' has the nasalized counterpart.

'Rhotacization' involves adding what may be called an 'r-coloring' to a vowel. It involves a modification of tongue shape and can be achieved by combining a curled-back tongue-tip gesture with an otherwise normal vowel articulation (but is not necessarily done that way by all speakers). It is common in North American English in such a vowel as that of *bird*.

With 'advanced tongue root' (ATR), and its converse, withdrawn or 'retracted' tongue root, we have an example of a property that is now included on the IPA chart but has not achieved a consensus of understanding among phoneticians. Pairs of vowels such as [i-ɪ] or [u-ʊ] are said to differ in that the first in each pair has the tongue root advanced, enlarging the pharynx. Opinions are divided over whether tongue root position is a separate controllable aspect of vowel articulation or whether, alternatively, it refers to vowel-quality differences that are already accommodated on the vowel quadrilateral. While one of the 20th century's leading phoneticians eagerly promoted tongue root position as an independently controllable aspect of articulation, and devised drills for his students to practice it (Pike, 1967), another (Catford, 2001) appears not to mention it.

Multiple Articulation

Certain consonant sounds require extensions to the simple voice-place-manner framework presented earlier in this article. Quite commonly, languages present pairs of segments that are alike in voice, place, and manner but distinct in sound because of an accompanying secondary adjustment. In the standard British pronunciation of English, for instance, a voiced alveolar lateral consonant that precedes a vowel at the beginning of a syllable (as in *look*) is very different in auditory effect from one that occurs after a vowel in the coda of a syllable (such as *cool*) that is accompanied by a raising of the back of the tongue (the sound is said to be 'velarized'). In this case, the difference is automatically conditioned and carries no meaning, but in many languages (for example, Russian) this type of difference is applied to numerous pairs of consonants and utilized to create linguistic contrasts. Along with 'velarization,' the most common types of secondary articulation found in languages are 'labialization' (the addition of a labial stricture, usually lip-rounding) and 'palatalization' (simultaneous raising of the front of the tongue towards the palate). A further kind of back modification, akin to velarization, but involving constriction of the pharynx, gives 'pharyngealization,' heard in the emphatic consonants of Arabic.

A distinct type of multiple articulation involves two simultaneous gestures of equal degree by independent articulators, termed 'double articulation.' For example, the Yoruba word 'arm' (part of the body) is [akpá], the [kp] denoting a voiceless plosive formed and released at the bilabial and velar places simultaneously. This is termed a 'labial-velar plosive.' In principle, many double articulations are possible, though only the combination of labial and velar is at all common. The common sound [w] is also a labial-velar double articulation (it is an approximant formed simultaneously at the two places).

Nonpulmonic Airstreams

Though the egressive pulmonic airstream is the basis of speech in all languages, certain languages supplement it with 'nonpulmonic' airstreams – that is, mechanisms that produce short-term compressions or rarefactions effected in the vocal tract itself and sufficient to power single consonant segments. The non-pulmonic sound types found in languages are 'ejectives,' 'implosives,' and 'clicks.' Ejectives, symbolized with an apostrophe [p' t' k' tʃ'] are the most common type. They resemble ordinary voiceless plosives and affricates, but are produced with a closed glottis, which is moved upward during the production, shortening the vocal tract and thus compressing the air contained between the glottis and the articulatory constriction (which might be, for example, at the lips). Release of the articulatory closure takes place (generally with a characteristic auditory effect, which can be relatively powerful), and the glottal closure is then maintained for at least a further short interval. The speaker will then generally return to the pulmonic airstream for the following sound. Much less commonly, languages may use the same mechanism to power a fricative. The mechanism used for ejectives can be called the 'egressive glottalic mechanism.' Because the vocal folds are closed, all sounds produced this way must lack vocal fold vibration.

'Implosives' can be viewed as reverse ejectives, made by moving the closed glottis down rather than up, giving the 'ingressive glottalic' mechanism. However, the voiceless types resulting from this straightforward reversal are rare in languages. The implosives commonly encountered are voiced and are symbolized with a rightward hook attached to the symbol for a voiced plosive, as in [ɓ ɗ ʛ]. In these, egressive lung air passes between the vibrating vocal folds at the same time as the larynx is in the process of lowering. The lung air offsets to some degree the pressure reduction caused by larynx lowering. The auditory effect resembles a strongly voiced plosive.

Ejectives and implosives invite comparison with ordinary pulmonic plosives and as recently as 1993 were accommodated as additional manners of articulation on the IPA consonant chart. By contrast, 'clicks,' which are found as linguistic sounds in relatively few languages, are really a class apart. They are brief but powerful sucking noises made by enclosing a volume of air in the mouth and then enlarging that volume by tongue movement, with a consequent reduction in pressure. The enclosed volume is invariably bounded at the back by the tongue in contact with the velum (yielding the term 'ingressive velaric' airstream); at the front, the closure may be completed by the lips or by the tongue tip and blade in various configurations. According to the place where the front of the closure is formed and released, clicks are categorized as bilabial, dental, (post)alveolar, palatoalveolar, and alveolar lateral. Basic clicks are of course voiceless, but because clicks are formed entirely within the mouth ahead of the velum, the rest of the vocal tract is free to perform a wide range of click 'accompaniments,' including voicing, aspiration, voice-plus-nasality, glottal closure, and others. No fewer than 13 accompaniments are described in Nakagawa (1995).

Beyond the Segment

Phonetic classification is almost entirely concerned with the paradigmatic axis of choice at each point in structure, and there is very little agreement on impressionistic description of structures extending along the temporal axis of speech (by contrast, much contemporary instrumental work is concerned precisely with the study of phrasal units in speech). Length, stress, and pitch are classified as suprasegmental (or prosodic) features on the current version of the IPA chart, implying that they apply not to single segments but to sequences. In fact, length often functions fairly straightforwardly as a segmental property, because languages often distinguish short and long vowels, and (less commonly) short and long consonants (the latter equivalently termed 'geminates'). Duration, loudness, and pitch are all contributors to the category stress (though in different proportions for different languages), with stress generally considered to be a property of a syllable rather than any particular segment within it. The phonetic syllable, however, is problematic, with some authorities claiming that definition is impossible. Nevertheless, phonetic taxonomies regularly make use of the concepts 'syllable division' and 'syllabicity,' and provide marks for indicating them in transcribed material. It is in the nature of the IPA stress-marks that they function additionally as syllable dividers. For still longer structures, agreement on impressionistic phonetic classification appears elusive. For example, attempts to categorize the seemingly characteristic rhythms of languages (as stress-timed vs. syllable-timed) have not met with lasting success.

A Consensus View

The basis of phonetic classification as summarized in this article is a consensus, forged over time, rather than the creation of any one figure or school. It can be found repeatedly in numerous works. One such work is in the IPA's *Handbook* (1999: 3–39), essentially the work of F. Nolan (see Nolan, 1995); another brief account, embedded in a wider scientific context, is the appendix, 'Overview of impressionistic-phonetic classification,' in Hayward (2000: 260–275). Phonetic classification, together with the development of practical skills in production and identification, generally forms the basis of introductory courses in phonetics (Ashby, 1995; Ladefoged, 2001). The main outlines of classification have been relatively stable since at least the 19th century, doubtless because it is based on a good basic understanding of relevant anatomy and physiology, and embodies a serviceable aerodynamic and acoustic model of speech sound production. The International Phonetic Association, through its journal and periodically revised alphabet, has played an important role in the emergence of this framework.

The 1989 convention at which the IPA's alphabet was comprehensively revised might have been expected to lead to corresponding revision in the phonetic classification (as was anticipated by Roach, 1986), but this did not happen. There is essentially nothing new about the classificatory scheme embodied in the revised alphabet or the new *Handbook* (1999).

Systematizers

Some have attempted comprehensive revisions of phonetic taxonomy, though it has been the usual fate of such schemes to have only a proportion of their proposals incorporated into the consensus view.

The two phoneticians who had the greatest influence on phonetic classification in the 20th century were K. L. Pike (1912–2000) and J. C. Catford. Pike's *Phonetics* (1943) is the most original systematic treatment of classification within the last century, but probably few now read or understand it. Much of Pike's terminology has passed into common use (for example, 'airstream mechanism,' 'local friction,' 'velic closure') but his rigorous stipulative definitions are forgotten. Even the famous 'vocoid' has become an imprecise term for any sound of a generally vowel-like character.

Catford's published contributions extend over more than 60 years and are comparable to Pike's in their completeness and rigor. The title, 'The articulatory possibilities of man' (Catford, 1968), gives an indication of the coverage attempted. As with Pike, although numerous terms and concepts have passed into common use, his overall scheme of classification has not. His table showing combinations of stricture type and location involves the intersection of 9 manners with some 26 places of articulation.

The dominance of the IPA style of taxonomy is not an indication that there are no viable alternatives. An interesting and original scheme for classification is that of Peterson and Shoup (1966), whose phonetic chart is reproduced in simplified form in Figure 4.

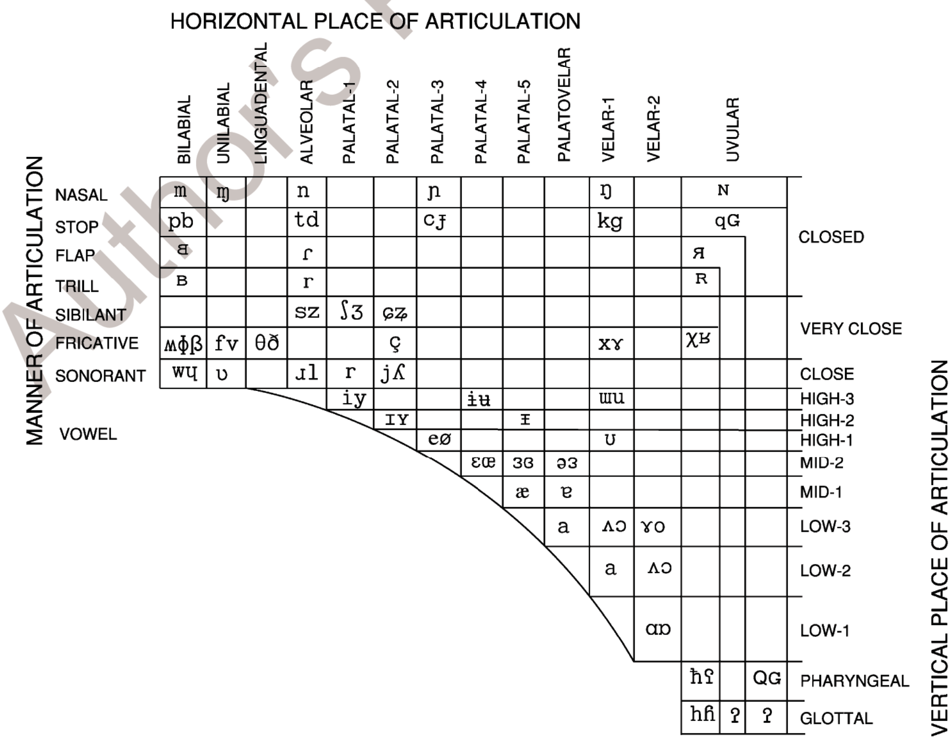


Figure 4 A portion of the phonetic chart of Peterson and Shoup (1966), considerably simplified.

Because of the way in which places and manners are defined, vowel and consonant articulations are integrated into one chart, showing, for example, the affinity between open vowels of type [a] and pharyngeal consonants. The arrangement of their chart automatically excludes impossible categories such as pharyngeal nasal (which the IPA must exclude by shading a cell in the grid). Also noteworthy is the recognition of sibilant as a manner of articulation separate from fricative (the failure to acknowledge the category 'sibilant' is one of the most surprising omissions of the IPA classification). Despite evident advantages, the Peterson and Shoup scheme appears to have had little impact.

Phonetics and Phonology

The publication of *The sound pattern of English* (Chomsky and Halle, 1968) brought a change in what is widely understood by the term 'phonetic theory.' Chapter 7 of the book, entitled, 'The phonetic framework,' contains a wide-ranging survey of phonetic classification seen from the viewpoint of the phonologist who requires a universal feature-set for linguistic analysis. Rather than favoring the proliferation of types and categories, such an enterprise prompts the search for underlying (and possibly somewhat abstract) similarities within what are superficially disparate appearances. It is, however, in danger of subordinating phonetic accuracy to the needs of an elegant feature system. It was partly in reaction to this that Peter Ladefoged developed his 'linguistic phonetics' (Ladefoged, 1971, and many subsequent publications). This retains much traditional terminology, and resembles the traditional IPA approach in that the total range of sound types to be described is taken to be a superset of attested language systems, which are arranged systematically and aligned in such a way that closely similar types in different languages are conflated. The total number of contrasting categories can then be determined, and the 'dimensions' or 'parameters' along which the categories differ can be sought. Linguistic phonetics is based on, and has stimulated, extensive valuable fieldwork, which is commonly supported by acoustic and articulatory instrumentation. Given this framework, the extensive contributions of Ladefoged and his coworkers have been pragmatic rather than philosophical. Ladefoged and Maddieson (1996) presents the closest approach yet seen to a comprehensive catalogue of human sound types, but the authors abstain from any reorganization of classification (see, however, 369–373).

Laver (1994) is probably the only extensive attempt at a novel systematization of classification in recent times. It presents an integration of classification within a very broad conception of the field of phonetics. Laver proposes that place of articulation and degree of stricture (for all segments) must be supplemented by a third factor, 'aspect' of articulation, which in turn consists of 'conformational,' 'topographical,' and 'transitional' elements. Into this aspect category he puts a wide variety of features, including the oral/nasal and central/lateral distinctions, retroflexion, ATR, and dynamic features such as tapping and trilling. It is a matter for debate whether this does more than save the appearances elegantly, by making both the place and degree-of-stricture dimensions more rational (see especially the discussion at 140–147).

Classification out of Fashion

A kind of paradox is associated with the study of phonetic classification. On the one hand, the IPA and the system of classification that underlies it are indispensable for practical use and are regarded as necessary prerequisites to more advanced study (for example, in language fieldwork, instrumental phonetics, or phonology). On the other hand, many of the basic concepts of traditional phonetic classification are widely held to be fundamentally flawed. The segment, for example, which is a cornerstone of the International Phonetic Alphabet, is very generally reckoned to be a kind of fiction, projected upon speech under the influence of alphabetic writing.

At the same time, systematic analysis of phonetic classification is now very much out of fashion as a contribution to research. It is noteworthy, for example, that among approximately 800 papers at the most recent International Congress of Phonetic Sciences, not one appears to address phonetic taxonomy directly (Solé, Recasens and Romero, 2003).

Probably many of those who use the International Phonetic Alphabet regard it as a practical tool and use it without any theoretical commitment to the taxonomy that the IPA seems to imply. Phonetic categories are seemingly not physical (in the sense of corresponding closely to acoustic or production data), nor yet linguistic (in the sense of corresponding to phonological features). In 'laboratory phonology' (Kingston and Beckman, 1990, and much further work), we see an enterprise founded on specifically ignoring the traditional taxonomic assumptions and thus bypassing phonetic classification and symbolization. It remains an open question whether, 'between the grammar and the physics of speech,' there is evidence for a level of phonetic representation as traditionally recognized.

See also: International Phonetic Association; Phonemics, Taxonomic; Phonetic Transcription: Analysis; Phonetic

Transcription: History; Phonetics, Articulatory; Phonetics: Overview.

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Phonetic Pedagogy

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Introduction

Although the teaching of phonetics today is an exciting matter that now even has its own conference (the biennial *Phonetics Teaching and Learning Conference* at UCL in London), we stand on a watershed. The technological revolution has opened doors to options we could previously only dream of and the need for phonetics (both practical skills and theoretical knowledge) has probably never been more in demand. In addition to the traditional market (linguists, speech therapists, and language teachers), a huge variety of other professionals are more speech-aware now than ever before, including forensics experts, voice and accent coaches, editors handling phonetic dictionaries (as well as language courses and travelers' phrase books), audiologists, hearing-aid technicians, teachers of the deaf, media employees (for example, both the *British Broadcasting Corporation* – as described in Pointon, 1988 – and the *Australian Broadcasting Corporation* in the English-speaking world have specific units dealing with matters of pronunciation), anthropologists, and linguistic fieldworkers (especially in connection with undertakings such as the SOAS-based Hans Rausing Endangered Languages Project) and technologists, programmers, and designers involved in the design and manufacture of all manner of speaking devices from banking machines to children's toys. At the same time, many governments are cutting funding, closing departments, and shrinking the crucial resource base, making this still rather costly subject to teach even more of a challenge to those employed in the field (and even casting doubt in some cases over our ability to continue training future generations).

Nevertheless, the combination of enhanced facilities and the widening range of 'consumers' has, necessarily, impacted on both the syllabus and the delivery of this subject.

There are still differing views over what the notion of phonetic pedagogy actually encompasses. A century ago, when the more widespread teaching of phonetics in the modern idiom first began (phonetics, of course, was around for many centuries before that), the focus was principally on phonetics applied to language teaching (see *inter alia* Catford, 1993). Today's International Phonetic Association (IPA) was cofounded in 1886 by a European group of

Vowel Description

Essential reading: Ashby & Maidment, Chapter 5

4.1 Aim: To introduce the basics of vowel description and the main characteristics of the vowels of RP English.

4.2 Definition of vowel: Vowels are produced without any major obstruction of the airflow; the intra-oral pressure stays low, and vowels are therefore sonorant sounds. Vowels are normally voiced. Vowels are articulated by raising some part of the **tongue body** (that is the front or the back of the tongue **not** the tip or blade) towards the roof of the oral cavity (see Figure 1).

4.3 **Front** vowels are produced by raising the front of the tongue towards the hard palate. **Back** vowels are produced by raising the back of the tongue towards the soft palate. **Central** vowels are produced by raising the centre part of the tongue towards the junction of the hard and soft palates.

4.4 The **height** of a vowel refers to the degree of raising of the relevant part of the tongue. If the tongue is raised so as to be close to the roof of the oral cavity then a **close** or **high** vowel is produced. If the tongue is only slightly raised, so that there is a wide gap between its highest point and the roof of the oral cavity, then an **open** or **low** vowel results. Vowels produced with tongue positions between high and low are sometimes called **mid**. Vowels between close and mid are called **half-close** (or high mid, or close mid – the terms are interchangeable); vowels between open and mid are **half-open** (or low mid, or open mid).

4.5 Vowel quality is also affected the position of the lips. The lips may be **rounded**, **neutral**, or **spread**. For most purposes a two-way classification of rounded and unrounded is adequate. With practice, one can learn to round or unround the lips independently of the tongue position. Adding lip rounding to a close front vowel [i], we obtain a vowel which is symbolised [y] and is like that heard in French *lune* [lyn] "moon" or *rue* [ry] "street". Adding rounding to a quality [e], we obtain [ø], a vowel heard in French *deux* [dø] "two". If conversely we take away rounding from [u], leaving the tongue position unchanged, we obtain [ɯ], an unrounded vowel like that which many Japanese have in a word such as *Fuji*.

4.6 Examples: Table 1 uses keywords from RP English to exemplify the three main aspects of vowel quality: location, height and lip posture. The shaded cells in the table indicate lip-rounding.

4.7 Monophthong vs diphthong: In certain languages (English is one) the quality of a vowel can change within a single syllable. Such vowel-glides are known as **diphthongs**. Vowels whose quality remains relatively constant are known as **monophthongs**. The diphthongs of RP English are shown in Table 2, where they are classified as **closing**, meaning that the final target quality is closer than that at the start, and **centring**, meaning that the glide is towards a [ə] quality. (Don't be misled by the spelling of vowels in English. For example, the vowel in *bead* in English is a monophthong, even though we use two vowel letters in the spelling. On the other hand, the vowel in the first syllable of *holy* is a diphthong in many accents, but it is spelled with just one alphabetic symbol).

4.8 The vowel quadrilateral: It was formerly thought that the location of the highest point of the tongue within the oral cavity directly determines vowel quality (though we now understand that view is a considerable oversimplification) Seen from the side, the area in the oral cavity within which the highest point of the tongue moves about to produce different vowels is roughly elliptical in shape; for convenience in drawing , this shape is regularised as the **vowel quadrilateral** of standard proportions (Figure 2). The quality of a particular vowel can be indicated by plotting its location somewhere on the diagram, meaning that the vowel *sounds* as if it is produced with the highest part of the tongue in the location shown. Strictly, then, the vowel quadrilateral represents an **auditory** space, rather than an accurate articulatory one. Lip-rounding is not indicated on the diagram in any standard way.

4.9 Cardinal Vowels: The phonetic symbols arranged around the quadrilateral in Figure 2 do not represent the vowel sounds of any particular language, but instead a range of language-independent qualities which can be used as reference points (the **cardinal** vowels. The cardinal vowels are auditorily agreed qualities and must be learnt from a teacher or from a recording.

There are in fact two sets of cardinal vowels the **primary** set [i e ɛ a ɑ ɔ o u], numbered 1 - 8, (in which 1 - 5 are unrounded and 6 - 8 rounded) and the **secondary set** [y ø œ ɶ ɒ ʌ ɤ ɯ], numbered 9 – 16 (Figure 3). The secondary cardinal vowels are related to the primary ones by reversing the lip-posture, so for example vowel 1 is close, front, unrounded and vowel 9 is close, front, rounded and vowel 8 is close, back rounded, so vowel 16 is close, back, unrounded

However, vowels 1 and 5 can be given an articulatory specification. No 1 is produced with the frontest, closest position of the tongue which does not produce audible friction and No 5 is produced with the backest, openest possible tongue position, again without audible friction. Notice that between close and open there are two mid heights. So [e] and [ɛ] represent unrounded mid front vowels differing somewhat in height, while [o] and [ɔ] are both rounded back vowels, with [ɔ] somewhat more open.

4.10 The vowels of the IPA (Figure 4). The vowel quadrilateral shown on the IPA chart incorporates all the cardinal vowels, together with a number of additional symbols to represent other commonly encountered vowel sounds, such as [æ] and [ə].

4.10 Vowel diacritics: Vowel quality can be symbolised by using diacritics attached to an appropriate (cardinal) vowel symbol. In the DIACRITICS part of the IPA chart (see Figure 5), the diacritics are shown attached to cardinal vowel No 2.

Obviously the diacritics can be used in combination, so the English KIT vowel, [ɪ] could be symbolised [ë̝] and the English vowel [ʊ] in a word like *put* could be symbolised [ö̝] if we wanted to start with a cardinal vowel symbol as basis.

4.11 Vowel quantity: Some languages make distinctive use of vowel length. A long vowel in such languages can be symbolised with a following length mark, thus [ɑ] is a short unrounded back open vowel and [ɑː] is its long counterpart. Maori (New Zealand) is one example of a language which has long and short versions of all its five vowel qualities. Most accents of English have vowel length distinctions, but usually the long and short members of a pair are also distinguished by clear quality differences as well.

	Front	Central	Back
Close (High)	FLEECE		GOOSE
Half-close (High-mid)	KIT		FOOT
Mid	DRESS	NURSE/commA	THOUGHT
Half-open (Low-mid)	TRAP		LOT
Open (low)		STRUT	START

Table 1. Approximate qualities of some RP vowels. (Shaded cells indicate lip-rounding). Compare the qualities plotted in Figure 6.

	Front starting point	Central starting point	Back starting point
Closing diphthongs	FACE		
		GOAT	
			CHOICE
	PRICE	MOUTH	

	Front starting point		Back starting point
Centring diphthongs	NEAR		CURE
	SQUARE		

Table 2. Classification of RP diphthongs. Compare the qualities plotted in Figure 6.

4.12 Ear training exercises

Q1 You will hear items of the form CVCV. Indicate whether the **first** vowel is rounded or unrounded.

1	rounded	unrounded
2	rounded	unrounded
3	rounded	unrounded
4	rounded	unrounded
5	rounded	unrounded

Q2 You will hear items which contain two vowels. Indicate whether the **second** vowel is front or not. If it is not front, it will be either central or back.

1	front	not front
2	front	not front
3	front	not front
4	front	not front
5	front	not front

Q3 You will hear items which contain one vowel. Indicate whether the vowel is a monophthong or a diphthong.

1	monophthong	diphthong
2	monophthong	diphthong
3	monophthong	diphthong
4	monophthong	diphthong
5	monophthong	diphthong

Q4 You will hear items which contain two vowels. Indicate whether the **first** vowel is high (=close mid or close) or low (=open mid or open).

1	high	low
2	high	low
3	high	low
4	high	low
5	high	low

4.13 Find the odd one out in each of the following sets of vowels, and say why:

(i) [ɑ i o ɒ ɯ]
(ii) [u ø ɒ e y]
(iii) [i y u o ɨ]
(iv) [ɛ a ɑ ɔ e]
(v) [y ɛ æ o œ]

4.14 Kirghiz vowel harmony. Kirghiz is a Turkic language spoken in parts of Afghanistan and China and in Khirgizia in Central Asia. Look at the list of words below. Each is given in its stem form and also in a form carrying a suffix meaning *with* or *by*.

Data from Comrie, B. (1981).The languages of the Soviet Union. Cambridge: Cambridge University Press. pp 59-61.

Stem form	Suffixed form	
[ɑlmɑ]	[ɑlmɑdɑn]	*apple*
[et]	[etten]	*meat*
[tuz]	[tuzdon]	*salt*
[tokoj]	[tokojdon]	*forest*
[iʃ]	[iʃten]	*work*
[køl]	[køldøn]	*lake*
[ʒɯl]	[ʒɯldɑn]	*year*
[yj]	[yjdøn]	*house*

(a) **What determines whether the first consonant of the suffix is [t] or [d]?**

(b) **Complete the following table using symbols from the Kirghiz words above.**

	Unrounded Vowels		Rounded Vowels	
	Front	Back	Front	Back
High				
Non-high				

(c) **From the evidence above, which of the following statements are true?**

All the vowels in a Kirghiz word agree in rounding.
All the vowels in a Kirghiz word agree in frontness or backness.
All the vowels in a Kirghiz word agree in being high or non-high.

(d) Kirghiz forms ordinal numbers (meaning *first, second, third* etc) by adding to the basic number words a suffix of the form [VntʃV], where both V's stand for high vowels. Here are some Kirghiz numbers. **What are the corresponding ordinal numbers?** (If the number ends in a vowel, the first V of the suffix is left out)

one	[bir]	*three*	[ytʃ]
four	[tørt]	*five*	[beʃ]
six	[ɑltɯ]	*nine*	[toguz]
ten	[on]	*twenty*	[ʒɯjɯrmɑ]

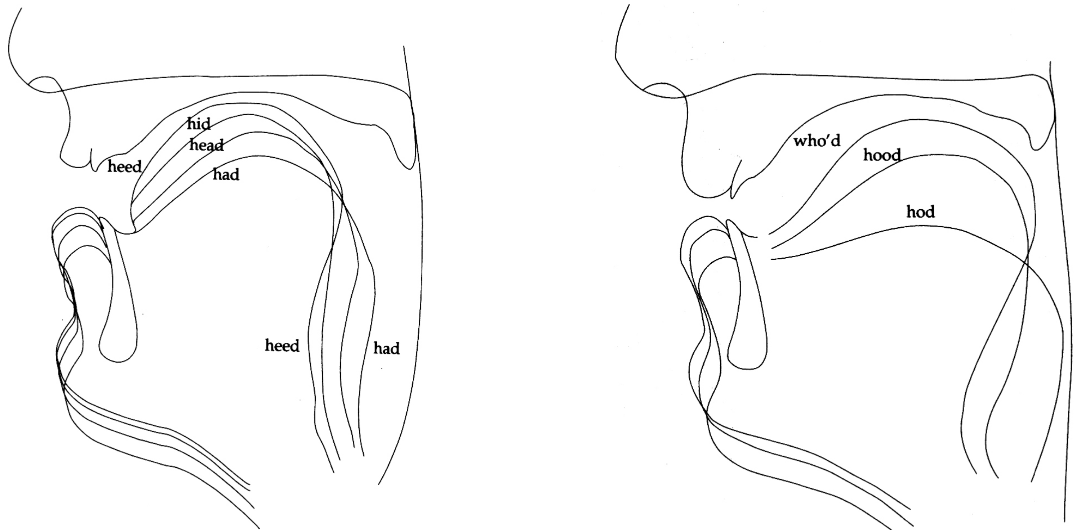
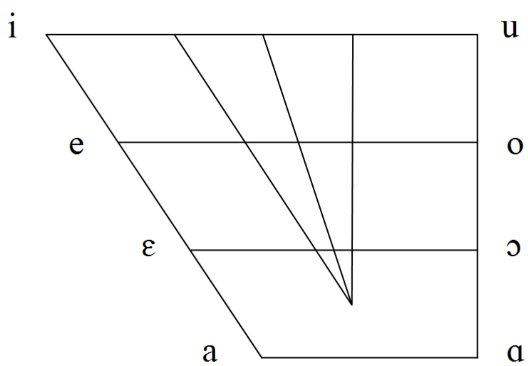


Figure 1. Tongue shapes in American English front vowels (left) and back vowels (right). X-ray data averaged over 5 speakers. From Ladefoged, P. (2005). *Vowels and consonants*. Second edition, Oxford: Blackwell. pages 122-123.



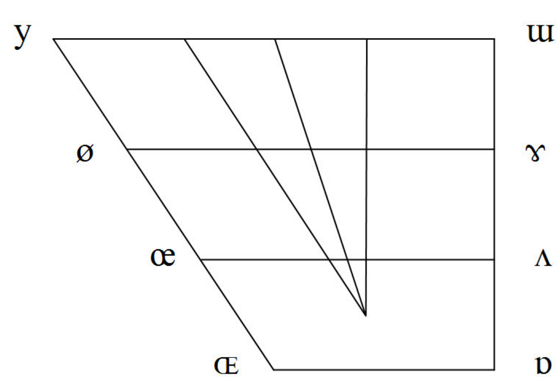


Figure 2. Primary cardinal vowels (left) and Figure 3, secondary cardinal vowels (right). From Ashby and Maidment (2005), page 78.

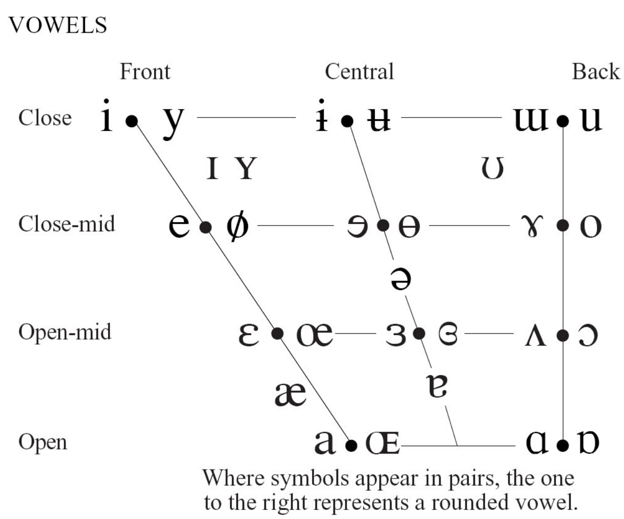
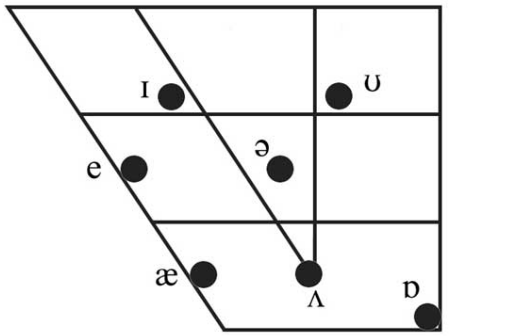


Figure 3. The vowel quadrilateral on the IPA chart.

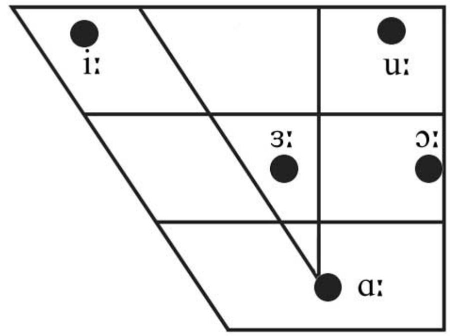
Figure 5. Vowel diacritics

ë	centralized
ę	lowered
ẹ	raised

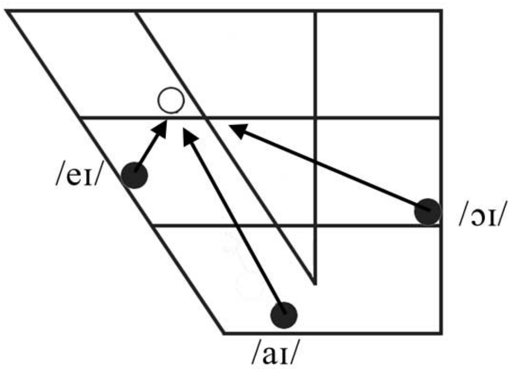
Figure 6. Approximate qualities of British English (RP) vowels and diphthongs.



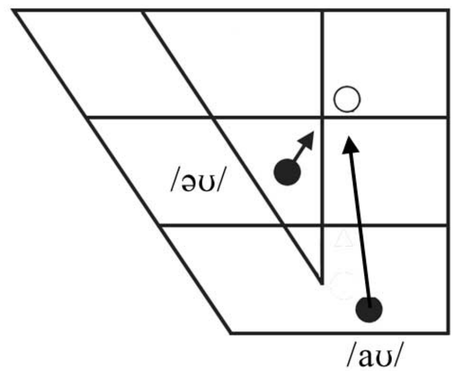
Short monophthongs



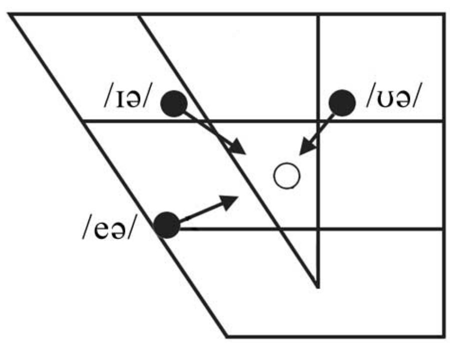
Long monophthongs



Diphthongs which close towards /ɪ/



Diphthongs which close towards /ʊ/



Centring diphthongs

3 Place and manner of articulation

Essential reading: Ashby and Maidment (2005) Chapters 3 & 4

3.1 Aim: To outline the production of consonant sounds in terms of their place and manner of articulation.

3.2 Having passed through the larynx, air enters the **vocal tract**, which is usually visualised at its central (mid-sagittal) plane, as seen in a lateral x-ray (see Figure 1). The lowest part is the **pharynx**. The vocal tract branches into the oral and nasal cavities. The entrance to the nasal cavity is controlled by the **velum** (or soft palate) which can be raised, forming a **velic** closure against the rear wall of the pharynx, thus preventing air from entering the nasal cavity, or lowered, allowing flow into the nasal cavity and thus out of the nostrils

The upper surface of the oral cavity is formed by the **hard palate**, and the moveable soft palate. Around the palate is a ridge holding the teeth; the portion of this behind the upper incisors is referred to as the **alveolar ridge**. Various parts of the tongue (see Figure 2) can be made to approach or touch the upper surface of the mouth, and complete airtight closures are possible at a range of locations, the closure being made not only on the mid-line where it is usually visualised, but across the width of the cavity and back along the tongue rims. The space between the teeth can be altered by adjusting the jaw opening, while the lips can assume a range of adjustments, again including complete closure.

3.3 The location along the vocal tract where a consonantal obstruction is formed is called the **place of articulation.** If a constriction is made at the lips or the glottis, there are two moving articulators; at other locations, there is generally a **passive** articulator (which does not move), and an **active** articulator (which moves toward the passive articulator). For most articulations the commonly used name is based on the passive articulator concerned. Places of articulation are listed in Table 1.

3.4 **Manner of articulation** refers to the type of obstruction used in the production of a consonant – whether, for example, the airflow is blocked completely for a brief time (yielding the manner known as **plosive**) or simply obstructed so that noisy turbulent flow occurs (the manner known as **fricative**) and so on.

Manners of articulation are summarised in Table 1. The main difference among manners is in degree of constriction, but manner also incorporates

- the **nasal/oral** distinction: the velum may be open as in [m] or [n], permitting flow via the nose, or closed)
- the **central/lateral** distinction: airflow is central – along the mid-line of the tract – in most sounds, but is diverted to the side(s), in lateral sounds such as [l].
- the **rate** of an articulatory manoeuvre; for instance, if the tongue tip and blade make one brief flick sealing against the alveolar ridge the resulting sound is called a tap, symbolised [ɾ] , but the same closure made at a slower rate will be a plosive.

	LABIAL		CORONAL				DORSAL				
place	**bilabial**	**labio-dental**	**dental**	**alveolar**	**post-alveolar**	**retroflex**	**palatal**	**velar**	**uvular**	**pharyngeal**	**glottal**
English sounds	p b m	f v	θ ð	t d s z l n	ʃ ʒ tʃ dʒ ɹ		j	k g ŋ			h ʔ
other sounds (sample)	ɸ β	ɱ				ʈ ɖ ʂ ʐ	c ɟ ç ʝ	x ɣ	q ɢ χ ʁ	ħ ʕ	
passive articulator		upper teeth	upper teeth	alveolar ridge	rear of alveolar ridge	hard palate	hard palate	velum	uvula, back of velum		
active articulator	lips	lower lip	tongue tip/blade	tongue tip/blade	tongue tip/blade	tongue tip	front of tongue body	back of tongue body	back of tongue body	epiglottis, tongue root	vocal folds

Table 1. Places of articulation

place	**labial-velar**
English sound	w
other sounds (sample)	k͡p g͡b
articulations	bilabial + velar

Table 1(a). Characteristics of English [w], which is a double articulation. Labial-velars commonly pattern like labials.

manner	English sounds	other sounds (sample)	stricture	sonorant or obstruent
plosive	p t k b d g (ʔ)	ʈ ɖ c ɟ q ɢ	closure (stop)	obstruent
nasal	m n ŋ	ɱ ɳ ɲ ɳ	oral closure (stop) + nasal airflow	sonorant
trill		ʙ r ʀ	repeated brief closures	sonorant
tap or flap		ɾ	one rapid closure	sonorant
fricative	f θ s ʃ v ð z ʒ h	ç x	constriction, turbulent flow	obstruent
lateral fricative		ɬ ɮ	median closure + lateral narrowing	obstruent
(central) approximant	w ɹ j	ɥ ɰ	wide approximation	sonorant
lateral approximant	l	ʎ ɭ	median closure + lateral wide approximation	sonorant
affricate	tʃ dʒ	p͡ɸ b͡β k͡x	closure (stop) followed by homorganic friction	obstruent

Table 2. Manners of articulation

3.5 Obstruent and Sonorant: Articulations may be divided into two large classes. All **obstruent** articulations share the characteristic of increased air pressure inside the vocal tract, which is caused by a radical obstruction of the route by which the airstream exits. Obstruent manners are plosive, fricative (including lateral fricative),and affricate,. In **sonorant** articulations the airstream is relatively unobstructed and there is little or no rise in air pressure inside the vocal tract. Sonorant manners are nasal, approximant, lateral approximant. Vowels are also sonorant.

3.6 Liquids and semivowels: [ɹ] and [l] sounds are usually distinguished from other approximants like [w] and [j] by the use of the term **liquid**. Approximants such as [j] and [w] articulated with the front or back of the tongue (not the tip or root) resemble short versions of vowels and are sometimes called **semi-vowels**.

3.7 Two sounds are said to be **homorganic** if they use the same articulators. So [p] and [b] are homorganic because they are both bilabial. Sometimes the term is applied more broadly, so for example [p] and [f] could be said to be (near-) homorganic because both are labial.

Exercises

3.8 Look at the following set of consonant symbols:

[t w f m k l]

Of the sounds they represent:

a) which are voiceless? ………………………………

b) which are plosives? ………………………………

c) which are fricatives? ………………………………

d) which are sonorants? ………………………………

e) which are alveolar? ………………………………

3.9 Circle the words:

(a) that begin with a bilabial consonant:

man fat psalm palm boat coat

(b) that begin with a velar consonant:

cod quick road know heart goat

(c) that begin with a labiodental consonant:

fat thick short cheese van meet

(d) that begin with an alveolar consonant:

zip not lid sat top den

(e) that begin with a dental consonant:

that song face thought week shape

(f) that end with a fricative:

wish rang beige boss raise force laugh edge breathe

(g) that end with a nasal:

line wing lamb may

(h) that end with a plosive:

bell tip lot dumb rub wide leg rough shock

(i) that begin with an approximant:

win you rose one use law

(j) in which the consonant in the middle is voiced:

looking weather busy robin fishing comic leisure

3.10 Transcribe the following words:

(1) plank (2) beep (3) easy (4) paper (5) votes (6) muddy

Now perform the following operations and retranscribe the words:

(a) delete all voiceless plosive sounds
(b) change all bilabials into alveolars of the same manner and voicing
(c) change all plosives into the nearest fricative
(d) change all voiced fricatives into voiced affricates

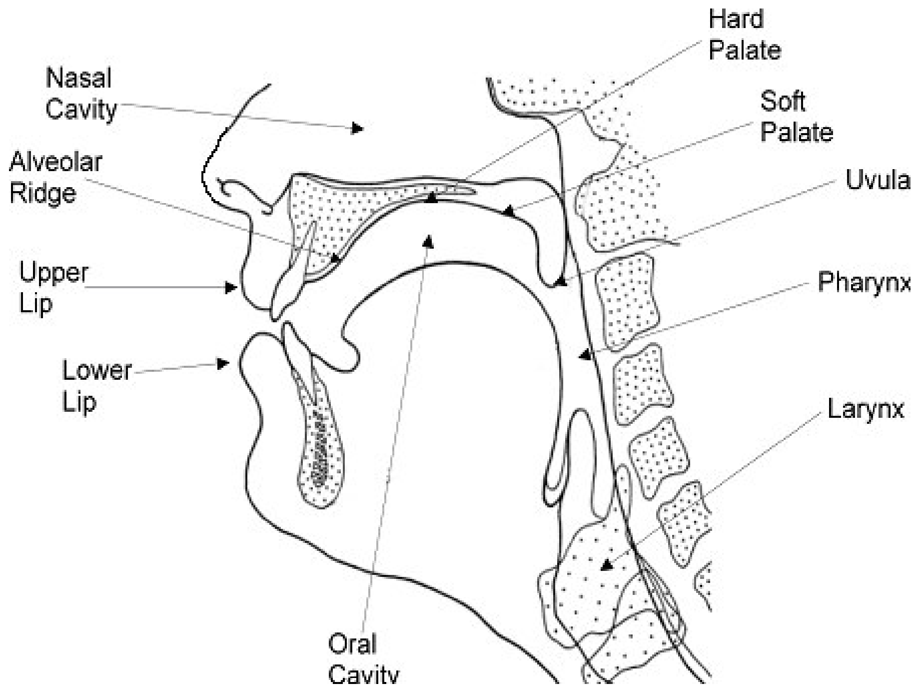


Figure 1 A mid-sagittal section of the vocal tract

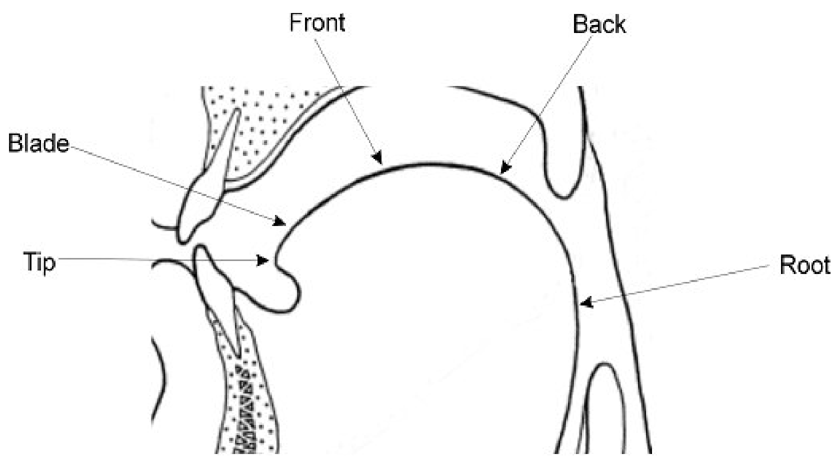
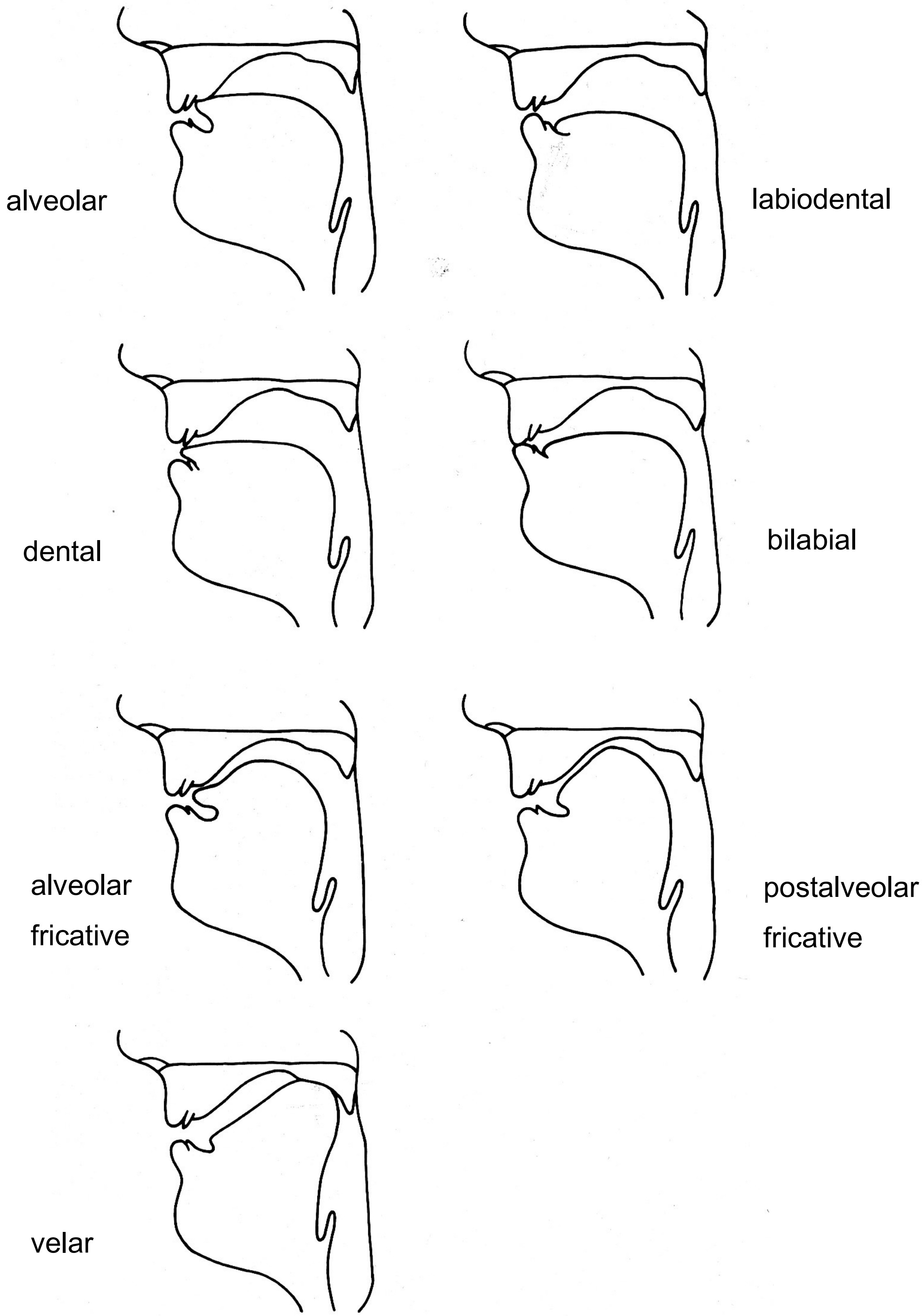


Figure 2. Areas of the tongue

Figure 3. Vocal tract outlines (after Ladefoged, *A course in phonetics*)



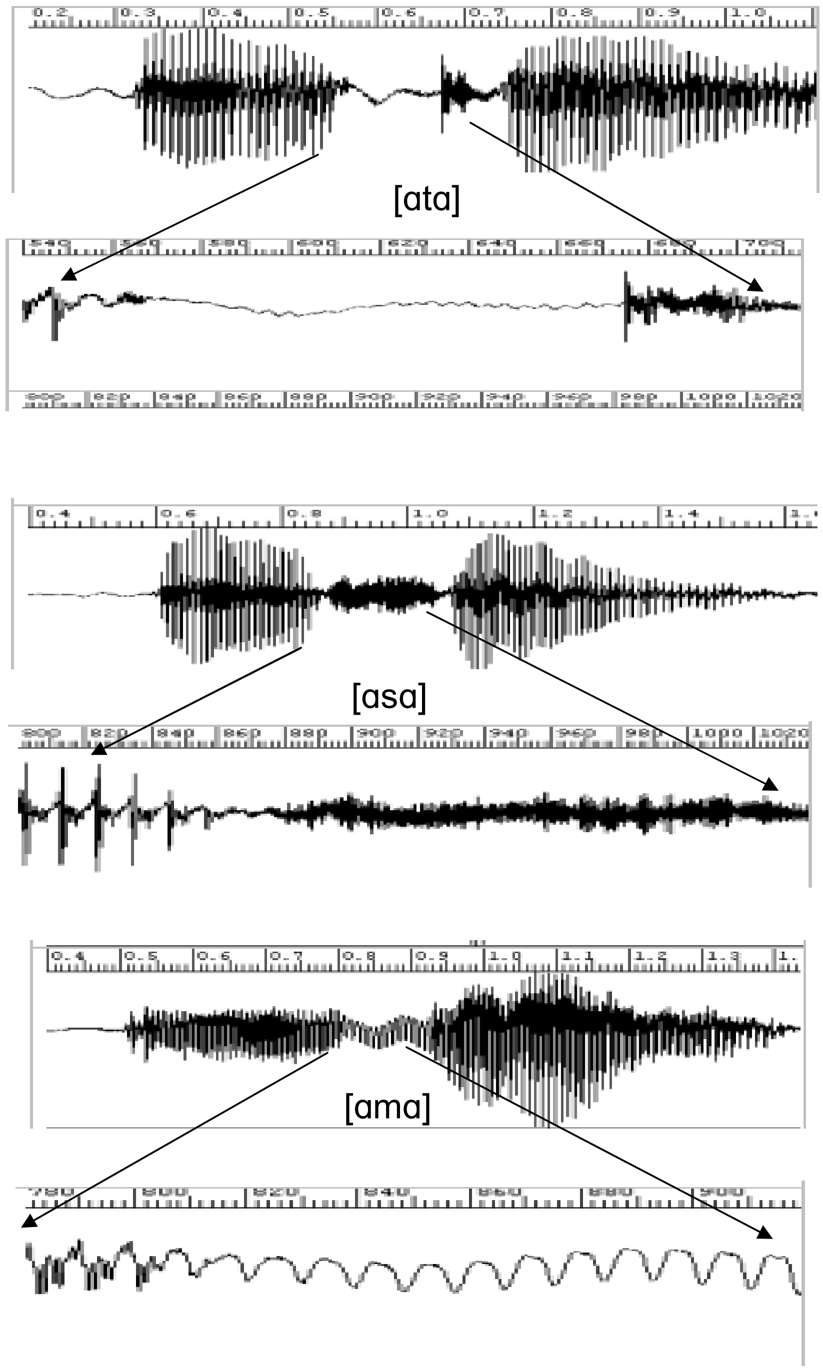


Figure 4. Speech waveforms illustrating plosive, fricative and nasal manners. The lower panels show a magnified portion from the middle of each sequence.

3.10 Ear Training Practice:

Q1 You will hear items of the form VCV. Indicate whether the consonant has audible friction or not.

1	audible friction	no audible friction
2	audible friction	no audible friction
3	audible friction	no audible friction
4	audible friction	no audible friction
5	audible friction	no audible friction

Q2 You will hear items which end with a consonant. Indicate whether the final consonant is velar or at some other place of articulation.

1	velar	other
2	velar	other
3	velar	other
4	velar	other
5	velar	other

Q3 You will hear items with varying structures. Indicate whether the items contain a median approximant or not.

1	yes	no
2	yes	no
3	yes	no
4	yes	no
5	yes	no

9 The IPA. Ejectives, implosives, clicks

Essential reading:
Ashby and Maidment (2005) Chapters 1 and 7.

9.1 The International Phonetic Alphabet aims to provide symbols for the sounds encountered in every language. One of the original Principles of the IPA expresses this aim as follows:

There should be a separate sign for each distinctive sound; that is, for each sound which, being used instead of another, in the same language, can change the meaning of a word.

Notice that this amounts to a statement of the phoneme principle. It means that the IPA should contain a suitable symbol for the principal allophone of any phoneme in any human language. See IPA *Handbook* (1999:27).

9.2 The range of possible human sound types is much larger than the set of sounds actually found in languages. The consonant chart on the alphabet of the IPA has several empty boxes, corresponding to articulations which have no symbols. For instance, there are no symbols in the box where the manner **lateral fricative** intersects with the place **palatal**. But palatal lateral fricatives can easily be made (and in fact fricative allophones of palatal laterals have been reported).

9.3 If a language is discovered which makes contrastive use of a sound which was previously no more than a *possible* human sound, then a new symbol will be required in the IPA. For instance the 1989 revision added a symbol [ʙ] for a voiced bilabial trill. Prior to 1977, the voiced bilabial trill was noted only as a possibility, but then it was reported that two languages, Kele and Titan (Papua New Guinea) have bilabial and tongue-tip trills in contrast. As a temporary measure, the investigators had used [ʙ] to represent the bilabial trill and that is the symbol that was eventually adopted for the IPA.

9.4 The 2005 revision added a new symbol [ⱱ] for the voiced labiodental flap, a sound now documented as occurring in more than 70 languages of north central Africa. (This symbol is available in the latest Unicode font, Charis SIL, with the code E25F).

9.5 **Air-stream mechanisms.** One important way in which consonant sounds can differ has not yet been considered: the use of different air-stream mechanisms. All the sounds we have considered so far have used the pulmonic airstream mechanism (air from the lungs). This is the basis of all normal speech in all languages, and many languages (e.g. English) use no other airstream. The lungs supply a large volume of air under pressure, enough to power the production of long stretches of speech without pauses for breath. However, small volumes of air (enough to power the production of a single consonant segment) can be compressed (or, alternatively, rarefied) by muscular action in the mouth or pharynx, without using lung air at all. Consonants produced this way are **ejectives**, **implosives** and **clicks**. These are very much like extra manners of articulation and were at one time put on the IPA chart as if they were manners of articulation; but they are now under "Consonants - Non Pulmonic". In the languages which use them, these non-pulmonic sounds are interspersed into speech like any other consonants.

9.6 **Ejectives** are the commonest type of non-pulmonic sound; they occur in many languages of America and Africa. Ejectives are symbolised by adding an apostrophe to the symbol for any voiceless obstruent [p’] [t’] [k’] [tʃ’] [s’]]. In the production of an ejective, the glottis is closed, and the air which is compressed (and eventually pushed out) is that between the closed glottis and the articulation in the oral cavity. For this reason, the name of the airstream is **egressive glottalic**.

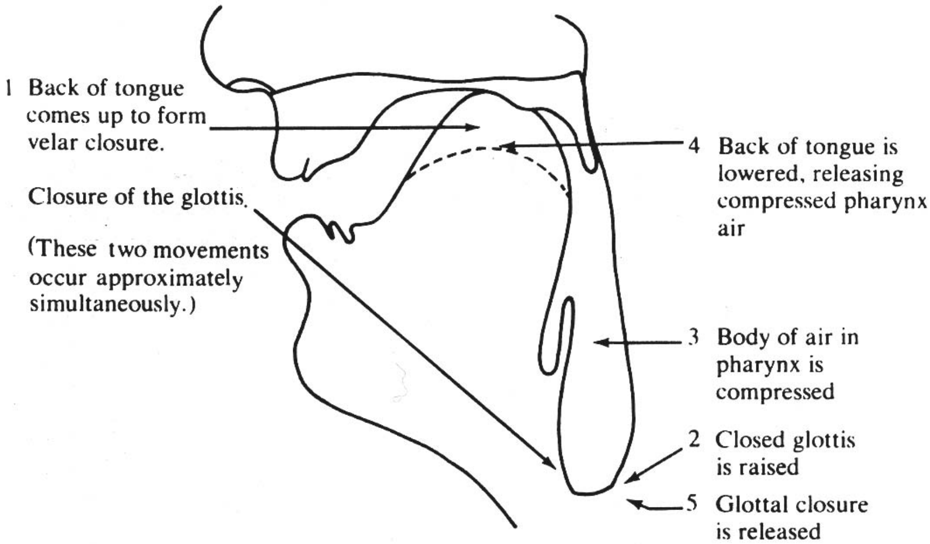


Figure 9.1 The sequence of events in the production of a typical ejective.

9.7 The sequence of events in the production of a voicless velar ejective plosive [k’] is as follows. Refer to figure 9.1.

(1) the back of the tongue rises to form a closure on the velum, just as for any velar stop. At about the same time, the glottis closes. The velum is also in its raised position, closed against the rear wall of the pharynx, so that no air can escape through the nose. (2) the closed glottis is raised (the whole larynx moves up) reducing the volume of the pharynx cavity and thus (3) increasing the pressure of the air in the pharynx. (4) the back of the tongue is lowered, just as for the release of an ordinary velar stop, thus releasing the compressed pharynx air and producing an audible explosion. The glottis remains closed during the release and for a short time afterwards. Finally (5) the glottal closure is released - for instance, the vocal folds may begin to vibrate for a following vowel. This description is of an ejective plosive, and this is the commonest type of ejective found in languages. Other types are possible, however, and ejective affricates and ejective fricatives are found in languages.

Occasionally, one encounters speakers of English who sometimes use ejectives as stylistic variants of ordinary English plosives at the ends of words.

9.8 **Implosives** are the next most common type of non-pulmonic sound. They occur in numerous languages of America, Africa and Asia. Implosives use the glottalic **ingressive** airstream; instead of moving up to compress the air in the pharynx, the glottis is moved down so as to enlarge the pharynx and produce suction. The symbols for implosives always have a hook attached to the top right: [ɓ ɗ ɠ].

Implosives are essentially reverse ejectives, but the straightforward voiceless examples are very rare in languages. The implosives commonly encountered have a further small complication in that they are voiced. Instead of being completely closed as it is pulled down, the glottis is vibrating to produce voice. Obviously, to produce voice, air from the lungs must be flowing up through the glottis. Voiced implosives thus employ two air-steam mechanisms simultaneously.

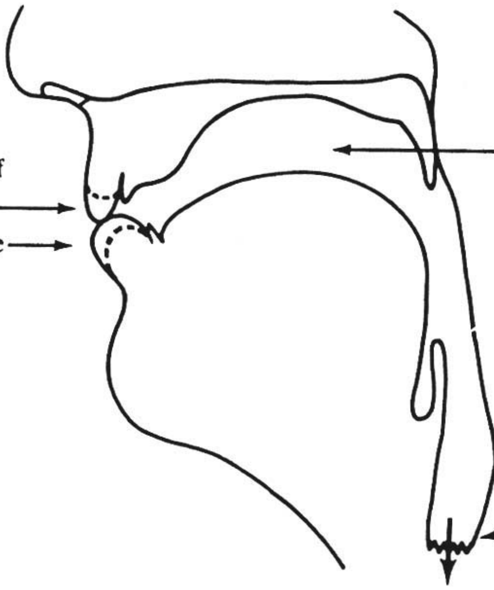


Figure 9.2 The sequence of events in the production of a typical implosive.

The sequence of events in a typical voiced implosive, [ɓ] is as follows. Refer to figure 9.2. (1) the lips close, as for any bilabial stop. (2) as the vocal folds continue vibrating in a flow of lung air, the whole larynx is moved down, thus enlarging the pharynx and tending to reduce the pressure of air inside it. (3) the reduction in air pressure may not be very great, because it is offset by further air from the lungs flowing through the glottis to keep vocal fold vibration going. When (4) the lips are opened, air pressure in the mouth is still a little below atmospheric pressure, so airflow (briefly) is inwards. An implosive is recognised not from ingressive flow but from the characteristic sound which results from the complex change of shape during the production of the consonant. The type of vocal fold vibration is also affected in a characteristic way.

Implosives sound like rather peculiar fully-voiced plosives. In certain languages, implosives contrast with voiced pulmonic plosives. In others (Swahili is an example) implosives occur, but as allophones of voiced plosives. Languages which have ejectives and implosives in contrast with each other are rare, but not unknown.

9.9 **Clicks** are found only in Southern Africa, in all of the Khoisan languages (this group includes the various Bushman languages) and also in certain neighbouring Southern Bantu languages (e.g. Zulu). The two groups are unrelated, and it is believed that the Bantu languages which have clicks must have borrowed them from

Khoisan. Clicks are not rare as paralinguistic signals - a kissing noise, the "tut-tut" of disapproval, the "clip-clop" in imitation of horses' hooves and the "gee-up" sound are all clicks. These are bilabial [ʘ], dental [ǀ], (post)alveolar [!] and alveolar lateral [ǁ]. Clicks use the ingressive velaric airstream.

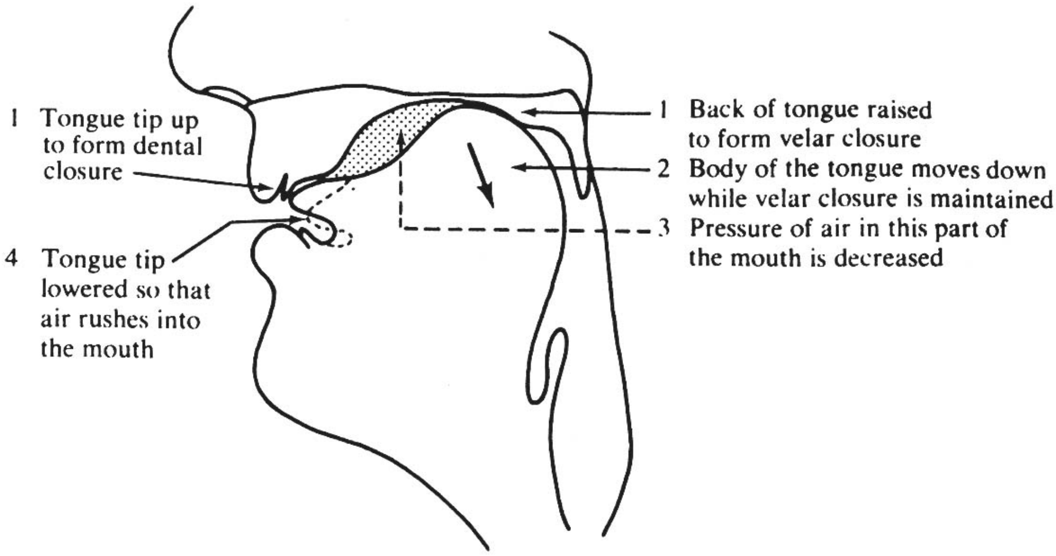


Figure 9.3 The sequence of events in the production of a typical click.

Refer to figure 9.3 for the estimated sequence of events in a Zulu dental click [ǀ]. (1) the tongue tip forms a dental closure, just as it would for a dental plosive. At the same time, the back of the tongue is raised to touch the velum, so that a small volume of air is trapped between the tongue and the upper surface of the mouth. (2) while the two closures are maintained, the body of the tongue moves down so as to enlarge the volume (and thus (3) decrease the pressure of the enclosed air). (4) the dental closure is released and a characteristic sound is heard as air rushes in.

Because clicks use only air in the mouth, the larynx and the nasal cavities can be used to add various modifications. If the velum is open and the vocal folds are vibrating, the click is said to be voiced and nasalized (it might be more accurate to say that the click is *accompanied by* voice and nasality). These are symbolized [ŋ͡ʘ] [ŋ͡ǀ] [ŋ͡!] [ŋ͡ǁ]. If a click is accompanied by voice, but not by nasality, the click is said to be voiced, and these are symbolized [ɡ͡ʘ] [ɡ͡ǀ] and so on. Clicks such as these which are voiced, or voiced-and-nasalized, use the pulmonic air-stream mechanism as well as the velaric.

References and resources

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Is supported by a website, with sounds and resources:
www.cambridge.org/0521004969 and follow links to resources

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Gordon, Raymond G., Jr. (ed.), 2005. *Ethnologue: Languages of the World*, Fifteenth edition. Dallas, Tex.: SIL International.
Online version: http://www.ethnologue.com/.

IPA (1999). *Handbook of the International Phonetic Association*. Cambridge: Cambridge University Press. ISBN 0-521-63751-1
(The sound files, illustrating abut 30 languages, can be downloaded from the IPA website)

Ladefoged, Peter (2005, 2nd edition). *Vowels and consonants*. Oxford: Blackwell. ISBN 1405124598X *(Includes a CD-ROM with many sound files) (Part of this is available free on Google Books)*

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UCL (2005) "Resources and tools" [World wide web document] URL: http://www.ucl.ac.uk/psychlangsci/research/speech/resources
(Includes free speech analysis software (SFS and Wasp), phonetic fonts, teaching and learning materials)

UCL (2005) "Phonetics and Linguistics Internet shopping" [World wide web document] URL: http://www.phon.ucl.ac.uk/shop/index.php
Recorded materials to buy, including the interactive CD-ROM of the sounds of the IPA.