LINGUISTICS: AN INTRODUCTION

Chapter 3: Phonology

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Note: This draft chapter was first written almost twenty years ago for a textbook that never got finished. (Or, to be more precise, my chapters were pretty much finished; my co-authors' chapter wasn't. Too bad, because we had a contract for the textbook with Oxford University Press.) One co-author, Richmond Thomason, also contributed to this chapter, though it was mainly written by me. The present version has been lightly revised.

Now that you have some knowledge of the basics of articulatory phonetics, so that you know how various individual speech sounds are pronounced, you're ready to think about how these sounds work together in languages. Linguists have discovered that each spoken human language has a quite regular sound pattern, and have developed techniques for inferring what this pattern is from linguistic data collected in interviews with native speakers or even from written texts. A language's sound pattern is called its **phonology**. The two basic units of phonology are the **phoneme,** for analyses focusing on entire segments and distinctive suprasegmental features, and the **distinctive feature,** for analyses focusing on patterns that involve particular phonetic features rather than whole segments or suprasegmentals.

In this chapter we will consider aspects of phonology that are manifested within single morphemes (roughly, single meaningful units). Many phonological processes, however, are relevant only across morpheme boundaries; these processes, traditionally called **morpho-phonemic rules,** will be discussed in Chapter 4, Morphology.

3.1. Phonemes and allophones

Phonemes aren't sounds: a phoneme may be pronounced differently in different positions in a word, and those varying pronunciations are the sounds. For instance, English has a single lateral phoneme, a voiced *l*. If we use the standard notation for phonemic representations, the slant lines / / (known as **phoneme brackets**), we can symbolize this phoneme as /l/. In most dialects of English the pronunciation, or **phonetic realization,** of this phoneme in word-initial position before a vowel, as in the word *loop* /lup/, is apicoalveolar, with the tongue body in a neutral position. This is the so-called 'clear *l*'. But in word-final position, the phoneme /l/ is realized phonetically as an apicoalveolar or apicopostalveolar

lateral with the tongue body moved back, a so-called 'dark *l*', as in *pool* /pul/. You can check this statement by pronouncing the words *loop* and *pool* in succession and listening for the difference in the *l* sounds, or by saying a word like *little,* in which both the clear *l* and the dark *l* occur. So, in this respect, phonemes are like amounts of money. You might at first think of a given amount of money, such as 25 cents, as something concrete, like a quarter. But actually it is an abstraction having various concrete realizations—a quarter, or twenty-five pennies, for instance. Like phonemes, amounts of money will be realized appropriately only in certain ways in certain contexts. A vending machine or a parking meter may take only quarters, and a small child may insist on pennies for her allowance. A phoneme is an abstraction in just the same way. It is conceived of as a single entity, but no phoneme has only one phonetic realization.

Speech sounds, or **phones,** are phonetic units that can be described without reference to any language—and that's how we did describe them in Chapter 2, though we also gave examples from particular languages. But phonemes exist *only* as parts of the sound system of their language; they are linguistic units embedded int hat system, not just the acoustic results of certain articulatory movements. Because the sound patterns of French and English are different systems, it would make no sense to speak of /m/ as the same phoneme in English and French, even though the phonetic realizations of French /m/ and English /m/ are quite similar.

Most simply, a phoneme can be defined as a phonological unit that fucntions, together with other phonemes of a language, to distinguish the words of that language. Or, to put it in another way, in any language the substitution of one phoneme for another in a wrod will make it a different word or a non-word. So, for example, if we substitute the English consonant phoneme /v/ for the phoneme /f/ in the word *fat,* we get another word: *vat.* Of course, it is not always the case that an arbitrary phonemic substitution will result in another word of the language. Substituting /l/ for /f/ in *fat* gives *lat,* a non-word of English; still, the meaning has changed—from a word meaning 'fat' to nonsense—and we certainly no longer have the same word as we did before we made the substitution. By contrast, if we switch the two *l*'s in the English word *little,* we still have the word *little.* But now it sounds rather strange.

We can also substitute sequences for a single phonemes, as for instance [sl] for the phoneme /f/ in *fit,* to yield *slit.* But this does not mean that the sequence [sl] is to be identified as a phonetic realization of a single phoneme in English, because a phoneme is the *smallest* whole segment that can be substituted for another to change meaning; and we can easily see that the sequence [sl] can be further divided if we consider words like *sit* and *lit,* each containing one component of [sl], substituted for the /f/ of *fit.* And if either [s] or [l] is further divided—say into phonetic features, e.g. 'voicelessness' for [s]—we no longer have an entire segment in the stream of speech.

This **distinctive** function of the phoneme is not only its defining quality, but also the key to its detection in an analysis of a language's sound system: if you want to discover the phonemes of a language, you must look for those segments which serve to distinguish words. Since most languages have at least some short words, and since relatively few languages have more than forty of forty-five phonemes in all, it is usually possible to find numerous pairs of words that differ only in one segment, e.g. English *fat* and *vat*, or *fat* and *fit*, or *fat* and *fan*. Such words are called **minimal pairs,** and they are a favorite tool of the linguist who wants to identify a language's set of phonemes. The use of minimal pairs in carrying out phonemic analysis will be discussed in more detail below.

Phonemic analysis has a lot in common with jigsaw and crossword puzzles: your task is to match bits (sound segments, wooden pieces, or letters) with other bits to form patterns. If you like puzzles, you should enjoy doing phonemic analyses, as long as you understand the two basic principles. Here they are:

- Two phones can't be realizations of the same phoneme if they ever **contrast,** that is, if they ever make a meaning difference in the same phonetic environment.
- Two phones, in order to be phonetic realizations, or **allophones,** of the same phoneme, must be phonetically similar.

Let's take the first principle first. What does it mean to 'make a meaning difference'? The example of *fat* and *vat* illustrates contrast between the labiodental fricatives [f] and [v] in the phonetic environment before the sound sequence [æt], in word-initial position. Their contrast is shown by the fact that *fat* and *vat* are different words in English. This last point is not as trivial as it looks at first. In a field situation, working on a language with which you are completely unfamiliar, you may well hear two quite different pronunciations to which a native speaker gives one meaning—say, [bef] and [bev], both of which, s/he says, mean 'fat'. The problem is to find out whether the two pronunciations represent one and the same word with nondistinctively different pronunciations, in which case [f] and [v] may belong to the same phoneme; or two different words, one perhaps meaning 'fat—grease' and the other meaning 'fat—heavily built', in which case [f] and [v] must belong to two separate phonemes, as they do in English. The reason you, the English-speaking linguist, notice the difference is that /f/ and /v/ are separate phonemes in your own language, and so you are hearing the difference. If the former alternative is the correct one, though, a speaker of that language will probably not notice the difference, any more than you normally perceive the two *l* sounds of *little* as being different.

In the same way, you probably don't notice it if you pronounce a word like *kitten* with an initial aspirated [k^h] on one occasion and with an initial fronted aspirated [k^{hy}] on another occasion, because this phonetic difference is not distinctive in English—there is only one /k/

phoneme. If, in English, you do pronounce *kitten* sometimes with a [k^{h}] and sometimes with a [k^{hy}], the two voiceless dorsovelar stops may be said to occur in **free variation** with one another, since they do not contrast. Speakers may choose either of these phones randomly, and their Engilsh-speaking listeners will not hear the difference. This same difference would be very apparent, however, to speakers of many languages, for instance North Caucasian languages of the former Soviet Union, where /k/ and [k^{y}] are separate phonemes.

But there is another thing that can happen: two phones may never occur in the same environment in words of the language. They are then said to be in **complementary distribution.** The example given above of dark *l* and clear *l* in English is a case of this sort, though a full description of their distributions is complicated. At any rate, take any English word in which dark *l* occurs. There will be no word of English in which clear *l* occurs in that same environment, and the reverse is of course also true. In other words, there will be no possibility of minimal pairs for clear *l* and dark *l* in English. They do not contrast, and they are phonetically similar sounds, so they must be allophones of the same /l/ phoneme.

As the term suggests, a minimal pair is a pair of words that differ minimally—specifically, as indicated above, in only one segment. *Fat* and *vat* constitute a minimal pair in English, but *fad* and *vat* do not, because they differ both in their initial and in their final segments. But again, difficulties with this point can arise in fieldwork. Suppose you are working on a language in which [f] and [v] seem to occur in the same sorts of environments—word-initially before all vowels, word-finally after all vowels, intervocalically (between two vowels), and so forth—but you can't find any actual minimal pairs, only near misses like *fad* and *vat*, *rife* and *drive*, and *rifle* and *arrival*. Must you therefore conclude that [f] and [v] are allophones of the same phoneme in the language? No indeed. Complementary distribution is a criterion of **patterning:** if you can find no easily statable pattern of complementary distribution, then you have no solid basis for grouping the phones in question into one phoneme.

The trick is to learn what counts as a plausible distributional pattern, and this will take time and practice. But it is not hard to see that a statement of "complementary distribution" based on the near-miss pairs above will be implausible: [f] in initial position when followed by [æd] but [v] when followed by [æt]; [f] in final position when preceded by [ray] alone but [v] when preceded by [dray]; and so on. Much too complicated. A typical pattern of complementary distribution will be quite simple, like the one that governed [f] and [v] in Old English, when the two phones **were** allophones of a single labiodental fricative phoneme, namely, the only labiodental fricative phoneme of Old English.

Look at the Old English (OE) words below, which are given both in OE spelling and in a broad phonetic transcription. Try to determine—from the phonetic representations, not the spellings!—the complementary distribution patterns of [f] and [v]. And try to solve the puzzle yourself before looking at the solution that follows the data!

		OE spelling	OE phonetics			OE spelling	OE phonetics
(1)	foot	fót	[fo:t]	(11)	weft	wefta	[wɛfta]
(2)	to find	findan	[fɪndan]	(12)	to weave	wefan	[wɛvan]
(3)	five	fíf	[fi:f]	(13)	loaves	hláfas	[hla:vas]
(4)	wolf	wulf	[wʊlf]	(14)	woman's	wífes	[wi:vɛs]
(5)	loaf	hláf	[hla:f]	(15)	thieves	þéofas	[θeəvas]
(6)	woman	wíf	[wi:f]	(16)	to give	ġiefan	[yɪəvan]
(7)	thief	þéof	[θeəf]	(17)	oven	of(e)n	[ɔn̩]
(8)	skill	cræft	[kræft]	(18)	ovens	ofnas	[ɔvnas]
(9)	gift	ġift	[yɪft]	(19)	raven	hræf(e)n	[hrævn̩]
(10)	to puff	pyffan	[püffan]	(20)	wolves	wulfas	[wʊlvas]

Here's what you should have discovered: in these twenty words, [f] occurs word-initially and word-finally, but [v] never does. So far so good; in these two positions, at least, [f] and [v] are in complementary distribution. But, since they can't be allophones of the same phoneme if they *ever* occur in the same position in different words, we have to look at word-internal (**medial** positions as well, and ehre both [f] and [v] occur (in words 8 through 20). Now the question you should ask yourself is this: can you give any general, simple phonetic description of the word-internal occurrences of [f] that will exclude [v], or vice versa? Well, [f] occurs in mid-word only after a vowel and before [t] (8, 9, 11) or next to another [f] (10); and [v] occurs medially between two vocoid vowels (12, 13, 14, 15, 16); between a vowel and [n] or [n̩] (18; 17, 19); or between [l] and a vowel (20). This statement is messy and complicated, but it can be greatly simplified: when [f] occurs medially, it is next to one voiceless sound. But when [v] occurs medially, it is always between two voiced sounds. In fact, the only environment [v] ever appears in, in these twenty words, is between two voiced sounds—and [f] never occurs in such a position. In all other environments, we find only [f]. We can therefore say that [f] and [v] are in complementary distribution: they never occur in the same environment, and the difference in their distributions can be stated as a general rule. Moreover, the general rule makes good phonetic sense: the voiced [v] occurs only in fully voiced environments—namely, between two voiced sounds—while the voiceless [f] occurs in environments that are partly voiceless (the beginning or end of the word counts as a voiceless environment, since the vocal cords aren't vibrating).

We now need a notation for describing environments. Think of an environment as a hole in a sound sequence. For instance, take the sequence [f] + [i] + [t], or [fit] *feet*. To describe the environment in which [i] occurs in this sequence, we simply replace it by a line _ _ and precede the whole thing by a slash; the slash is a sign showing that we're talking about an environment, and it translates to 'in the environment of'. So this is the environment in which [i] occurs in *feet*:

/f__t

As we've seen from the OE examples, beginnings and ends of words may be phonetically and phonologically significant. We can represent word-initial and word-final positions by introducing a symbol #, signifying word boundary—either end of a word. So this is the environment in which [f] occurs in *feet*:

/#__it

And this is the environment of [t] in the same word:

/fi__

Now we can state the distributions of the OE allophones [f] and [v] as follows:

(a)	[f]:	(1)	/ #__
		(2)	/ __#
		(3)	/ __[-voice]
		(4)	/ [-voice]__
(b)	[v]:		/ [+voice]__[+voice]

In these distributional statements, [-voice] means 'any voiceless segment', and [+voice] means 'any voiced segment (either a vowel or a consonant').

Obviously, it's only the distribution of [v] that is neat and simple. The allophone [f] occurs in a much less restricted, and hence more complex, set of environments. This is a typical situation: most, though by no means all, phonemes turn out to have one or more allophones with restricted distributions and only one allophone (if any) with a considerably wider distribution. The usual way of stating allophonic distributions is therefore to list only the restricted environments, and to specify the less restricted allophone's distribution simply as 'elsewhere'. So the distribution of these two OE allophones, on the basis of the data given above, are best represented as follows:

(a)	[v]	/ [+voice]__[+voice]
(b)	[f]:	/ elsewhere

The symbol chosen to represent the phoneme itself is most often the phonetic symbol for the 'elsewhere' allophone, if there is one. The reason for this choice is that it is easier to write a rule predicting when a phonetic realization [v] will be derived from a phoneme /f/ than to write a rule predicting when a phonetic realization [f] will be derived from a

phoneme /v/. That is, if we specify the phoneme as basically voiceless, we can simply state that it becomes voiced between voiced segments; but if we specify the phoneme as basically voiced, stating when it becomes voiceless requires more complicated rules. Thus the OE word for 'loaf', for instance, will have the **phonemic representation** /hla:f/, with the phonetic realization [hla:f], while the OE word for 'loaves' will have the phonemic representation /hla:fas/, with the phonetic realization [hla:vas]. To put it another way, both [f] and [v] are phonetic realizations of the **underlying phoneme** /f/; this phoneme is realized phonetically as voiceless [f] unless it occurs between two voiced sounds, in which case it is realized as voiced [v].

Notice that in solving this problem, or any other phonemic problem with such a small amount of data, we have to make one crucial assumption: the data provided are assumed to be representative of the language as a whole. So, for instance, if [v] occurs here between [ɛ] and [a] (12), between [ə] and [a] (15, 16), between [a:] and [a] (13), between [i:] and [ɛ] (14), between [ɔ] and [n̥] (17), and between [æ] and [n̥], then we assume—since [f] never appears between any two voiced sounds in these twenty words—that [v] can appear between any arbitrary pair of OE vowels, not just between these particular pairs of vowels. In this respect, limited-data problems differ markedly from fieldwork situations. In the latter, the linguist's task is to continue to elicit more and more data from his/her consultants until s/he is sure beyong reasonable doubt that the analysis is correct. S/he must not make such broad assumptions without evidence to support them, although of course s/he may construct hypotheses after examining a small amount of data—as long as s/he goes on to test these hypotheses carefully on more data. With a dead language like Old English, the linguist naturally cannot elicit data directly from native speakers, but must rely instead on the available texts. In a case l ike that of the OE [f] and [v] phones, s/he will search whatever data sources are available in an effort to prove that [v] can occur between any two voiced sounds and that [f] cannot. (This is a straightforward investigation only when the orthographic system corresponds in a one-to-one way with the phones under investigation. Unfortunately, it usually doesn't, and in such cases—which include Old English—philological analysis is needed to figure out which phones occurred where.)

In the classroom, though, there is rarely time for students to examine hundreds of words at a time in their search for patterns of complementary distribution, so we have to make use of the convenient fiction that allows us to extend our hypothesis from the few specific environments given in a problem to all similar environments. This is a harmless practice as long as students understand the difference between the methodology apporopriate to short problems and the requirements of a full-scale phonemic analysis.

There is another sort of check on the validity of our analysis of OE [f] and [v] besides the neatness and simplicity of the complementary distribution pattern we have discovered. This other method is indirect, and it is based on a belief that is firmly entrenched in the lore

of modern linguistics: linguistic structures tend toward symmetry. Unfortunately, we can never count on finding *absolute* symmetry in any aspect of a language's structure, because no language is that orderly. Nevertheless, symmetrical structures are extremely common at all levels, and their presence often provides strong evidence in favor of a proposed analysis.

In the OE case, we have hypothesized a certain distributional pattern for voiced and voiceless allophones of an OE fricative phoneme /f/. The next question we should ask is, what about other OE fricatives? If they follow the same pattern, then our hypothesis is strengthened, and we can simplify our distributional statement still further. If they don't follow it, then we should go back and check our hypothesis again, carefully, to make sure we've made no mistake.

So, here is another set of OE words. What can you say about the distribution of the fricatives [s], [z], [θ], and [ð]? Again, try to analyze the data yourself before looking at the solution below.

	OE spelling	OE phonetics		OE spelling	OE phonetics
(21) to sew	siwian	[sɪwɪn]	(33) nose	nosu	[nɔzʊ]
(22) sun	sunne	[sʊnnᴇ]	(34) to choose	céosan	[če:əzan]
(23) son	sunu	[sʊnʊ]	(35) to rise	rísan	[ri:zan]
(24) sister	sweostor	[swᴇəstɔr]	(36) bosom	bós(o)m	[bo:zm̩]
(25) horse	hors	[hɔrs]	(37) thorn	þorn	[θɔrn]
(26) man's	mannes	[mannᴇs]	(38) thief	þéof	[θe:əf]
(27) chose	céas	[čæ:əs]	(39) worth	weorð	[wᴇərθ]
(28) arose	rás	[ra:s]	(40) bath	bæð	[bæθ]
(29) house	hus	[hu:s]	(41) moth	moððe	[mɔððᴇ]
(30) to miss	missan	[mɪssan]	(42) to bathe	baðian	[baðɪan]
(31) mass	mæsse	[mæssᴇ]	(43) worthy	wyrðe	[wurðᴇ]
(32) east	éast	[æːəst]	(44) brother	bróþor	[bro:ðɔr]

If you found that the distributions of [s] and [θ] matched that of [f], while the distributions of their voiced counterparts [z] and [ð] matched that of [v], you were quite right. Both [s] and [θ] occur initially, finally, and medially next to one voiceless sound (including [s] and [θ] themselves); [z] and [ð] occur only medially between voiced sounds. As with /f/, the 'elsewhere' allophones are thus [s] and [θ] , so we have these three fricative phonemes in OE:

/f/: [v] / [+voice]__[+voice]
[f] / elsewhere

/s/: [z] / [+voice]__[+voice]
[s] / elsewhere

/θ/: [ð] / [+voice]__[+voice]
[θ] / elsewhere

These distributional statements are both correct and gratifyingly symmetrical, but they can be simplified. Since /f/, /s/, and /θ/ are the only fricative phonemes in the language, we can make a more general statement about the phonetic realizations of OE fricatives: any OE fricative is voiced between voiced sounds and voiceless everywhere else. (This statement fits the data we've seen, but it would have to be adjusted in one minor way if we took into account certain features of OE stress.) In a semi-formal notation, we can express this generalization as follows:

$$\text{fricatives} \rightarrow [+\text{voice}] \; /[+\text{voice}]__[+\text{voice}]$$

The arrow → is to be read 'becomes', and the whole statement is a **phonological rule** that specifies the only environment in which OE fricatives become voiced. So, as we noted above for /f/, all three fricatives are treated as basically ('elsewhere') voiceless: unless the proper environment is present, so that this voicing rule can apply to the fricative, the fricative will be realized phonetically as a voiceless segment. We do not need to say which particular fricative phoneme—/f/, /s/, or /θ/—can undergo the rule, because it applies equally to all three of them.

The fact that we can write such a simple rule to specify the occurrence of the voiced allophones of the there OE fricatives is a strong indication of the validity of our proposed analysis. Our hypothesis about [f] and [v], given the small amount of data, would be somewhat less certain, weaker, if it had turned out that /s/ and /θ/ followed different patterns.

But another problem arises here, one that brings us to the second bassic principle of phonemic analysis—namely, the principle of **phonetic similarity,** which was stated early in this chapter. The voiceless phone [f] is in complementary distribution not only with [v], but also with the other two voiced fricatives, [z] and [ð]. The same is true of the other two voiceless fricatives and, of course, vice versa—each voiced fricative is in complementary distribution with all three voiceless fricatives. So how do we decide which voiced/voiceless pairs to group together into phonemes? What principle keeps us from setting up a phoneme /f/ containing the two allophones [f] and [z], for instance?

The answer is that two phones, in order to be classed as allophones of the same phoneme, must be phonetically similar in addition to being in comlementary distribution or free variation with each other. Normally, two allophones of one phoneme will be more similar to each other phonetically than either is to any other sound in that particular language—that is, they will share some phonetic feature, or set of features, not found in any other phone in the language. (One finds occasional exceptions to this last requirement, but we will not be meeting any in this book.) For instance, dark *l* and clear *l*, together with labialized and palatalized variants in appropriate environments, are the only lateral phones in Modern English; and [f] and [v] were the only labiodental fricatives in Old English.

Methodologically, the criterion of phonetic similarity would be expecgted to apply before the criterion of complementary in carrying out a phonemic analysis, because there is no point in comparing the distributions of sounds that are too dissimilar to be plausible members of the same phoneme. For example, we would not be likely to compare the distributions of [f] and [z] in the first place, and certainly not when the language has a [v] as well as a [z]: [f] and [v] are pronounced exactly alike except for the phonetic feature of voicing, while [f] and [z] have different sets of articulators (labiodental vs. apicoalveolar) besides the difference in voicing. All the features shared by [f] and [z], most notably their fricative manner of articulation, are also shared by [v] and other fricatives as well.

Unfortunately for both beginning students and professional linguists, judging phonetic similarity is not always as easy as in the case of the OE fricatives. The best strategy is to learn what counts as a **natural class** of sounds—that is, sounds that tend to pattern together in languages. Labiodentals constitute a natural class; so do other place-of-articulation categories, i.e. the columns in the consonant and vowel charts we saw in Chapter 2, and also the rows in the vowel chart. Manners of articulation, which are laid out in rows in the consonant chart, also constitute natural classes of sounds. Other natural classes are voiced/voiceless pairs of sounds, oral/nasal pairs, plain/labialized pairs, plain/aspirated pairs, plain/palatalized pairs, and other such pairs that differ in just one phonetic feature.

It is even harder to learn what counts as a plausible pattern of complementary distribution. The major problem is to gain some skill in spotting common types of environments. We have seen, or at least mentioned, several in the Old English problem: word-initial and word-final positions, intervocalic position, and voiced environments vs. voiceless ones. You can find clues to other common types of environments by looking at the phonetic categories on the consonant and vowel charts in Chapter 2, because natural classes of sounds frequently constitute relevant allophonic environments as well as groupings of allophones in phonemes. For example, a given consonant phoneme might have one allophone before front vowels and another before back vowels; and a vowel phoneme might have a nasalized allophone before nasal consonants and an oral allophone before oral consonants. And so forth.

But the best way to gain skill in phonemic analysis is to carry out phonemic analyses,

and so to build up a store of first-hand information about a variety of phonetic environments that condition, or determine, allophonic alternations. You should practice by yourself on problem sets; meanwhile, however, a few moer demonstration examplse will help fix in your mind the appropriate techniques.

Below are eight words of Tojolabal, a Mayan language spoken in Mexico. (All the Tojolabal forms in this section are from H.A. Gleason's 1955 *Workbook in Descriptive Linguistics.*) These words contain three different voiceless apical (oral) stops: a plain unaspirated [t], an aspirated [t^h], and a glottalized [t']. For the moment, forget the glottalized stop and concentrate on the other two. According to the evidence provided by these eight words, is the difference between [t] and [t^h] phonemic, or are the two phones allophones of a single plain (i.e. nonglottalized) voiceless apical stop phoneme? Certainly the two stops are sufficiently similar phonetically to belong to a single phoneme, since they are the only two nonglottalized voiceless apical stops in the language, so the only question has to do with their distribution: do they contrast?

Tojolabal

(1) pig	čitam	(5) a kind of plant	čatat^h
(2) a patch	makton	(6) chicken	mut^h
(3) a kind of plant	potot'	(7) long	nahat^h
(4) upside down	tinan	(8) seed	ʔinat^h

Again, look at the environments in which each of the two phones occurs. Can you make a simple, general statement about the distribution of either one, or both? Well, unaspirated [t] occurs intervocalically (1, 3, 5), initially (4), and medially between [k] and a vowel (2). This set of environments doesn't look very promising as a nice simple distributional pattern. The aspirated stop t^h presents a different picture, though: it only occurs in one position, namely, word-finally. But this seems to be the one position where [t] never occurs. We can therefore conclude that [t] and [t^h] are in complementary distribution, and that they are therefore allophones of the same phoneme /t/. And we can state the relevant environments for the phoneme /t/ as follows:

/t/ [t^h] /__#
[t] / elsewhere

If we assume that the plain voiceless apical (oral) stop is basically unaspirated, we can write a semi-formal phonological rule specifying the only environment in which it has an aspirated realization:

/t/ → [+aspirated] /__#

Unless this rule can apply, the phoneme /t/ will be realized phonetically as an unaspirated, or [-aspirated] ('minus aspirated') phone.

As with the OE fricatives, the next step (or one of the possible next steps) is to see if we can strengthen our hypothesis about /t/ by finding parallel distributions of allophones in other nonglottalized voiceless stop phones. So, consider the voiceless velar stops in the following twelve words of Tojolabal:

Tojolabal

(9)	my beard	kisim	(15) chop it down	čak'a
(10)	our feet	koktik^{h}	(16) flea	k'ak^{h}
(11)	hanging	p'akan	(17) sugar cane	k'aʔem
(12)	white	sak^{h}	(18) warm	k'išin
(13)	he is carrying it	skuču	(19) to dress	k'uutes
(14)	he stirred it	snika	(20) reed	ʔak'

Here again, ignore the glottalized stop for the time being, and concentrate instead on the plain voiceless unaspirated velar stop [k] and the voiceless aspirated velar stop [k^{h}]. It won't have taken you long to discover that the distribution of [k^{h}] is identical to that of [t^{h}]: both occur only in word-final position. And [k] and [t] have almost identical distributions, differing only in that [k] occurs medially between a vowel and [t] (2, 10), while [t] occurs medially between [k] and a vowel (2, 10). Both [k] and [t] occur initially and intervocalically. The difference in their distributions is not significant here, since it does not disturb the hypothesized pattern of complementary distribution: aspirated stops in word-final position, unaspirated stops everywhere else.

Now, we know that the language also has a phone [p], but we have no evidence about its distribution, except its one occurrence initially (3). Nevertheless, subject to checking against other occurrences of plain voiceless labial stops, we can tentatively write the following general phonological rule:

stops → [+aspirated] /__#
[-voice]
[-glottalized]

That is, (oral) stops that are voiceless ('minus voice') and nonglottalized ('minus glottalized') are realized phonetically as aspirated stops always and only in word-final position. Elsewhere, they are unaspirated.

Now let's turn to the glottalized stops in the Tojolabal data. Glottalized [p'] (11) and [t'] (3) occur only once each, so we haven't much hope of discovering anything significant about their distributions. But the glottalized velar stop [k'] occurs in several words (15-20), so it is worthwhile to cmopare its distribution with those of the other voiceless velar stops. The question is basically the same: is the phonetic difference between [k'], on the one hand, and [k] and [k^h], on the other, phonemic, or are all three phones allophones of a single voiceless velar stop phoneme? Again, the question has to do with their distributions, because all three are similar enough phonetically to be grouped into a single phoneme; they are the only voiceless dorsalvelar stops in the language.

Notice that, given our current hypothesis that [k] and [k^h] belong to the same phoneme, we are tentatively comparing [k'] with the phonemic unit /k/—that is, with the sum of its two allophones' distributions. However, **if** it should turn out that [k'] is in complementary distribution with [k], for instance, but **not** with [k^h], then we would have to reconsider our original grouping of [k] with [k^h]. We would have to try to decide, in fact, which phone, [k'] or [k^h], is more similar to [k] phonetically, and gruop that one with [k] into a single phoneme. In this particular case, the decision would be a hard one, though the two pulmonic egressive phones [k] and [k^h] would probably still be grouped together, as opposed to glottalic egressive [k']. Luckily, we don't have to make the decision, because [k'] contrasts with both [k] and [k^h].

Glottalized [k'] occurs initially (16, 17, 18, 19) and intervocalically (15), like [k], and it occurs fnially (20), like [k^h]. In this set of data it does not occur medially next to another consonant, as [k] does; but this does not matter, since any one position of contrast—initial or intervocalic, in this case—is enough to force us to put [k'] and [k] into separate phonemes. They need not contrast in all their environments.

Notice that there are no minimal pairs for either [k'] and [k] or [k'] and [k^h]. This doesn't matter either, because there is no plausible *pattern* of complementary distribution for [k'] with either [k] or [k^h]. The phones [k] and [k'] occur in very similar, though not identical, environments initially before [i] in words (9) and (18), while [k'] and [k^h] occur in similar environments finally after [a] in (12), (16), and (20).

These similar environments illustrate an important procedural rule of phonemic analysis: always look at the immediate environment of a phone first, because the closest sounds in the speech stream (or word boundary, if the phone in question is at either end of a word) are the sounds most likely to influence its pronunciation. So, for instance, a fully voiced immediate environment influenced, or **conditioned**, the voicing of OE fricatives. It is much less common for nonadjacent segments, or word boundaries, to condition an allophonic alternation, especially in consonant phonemes, though it does happen. But in the Tojolabal example, [k'] occurs in some of the same immediate environments as [k] and [k^h]. Only the nonadjacent sounds differ, and there is, as noted above, no evidence in the data to indicate

that those nonadjacent sounds in words (9) and (18), or in words (12), (16), and (20), constitute a pattern of complementary distribution.

You should therefore conclude that Tojolabal has two voiceless velar stop phonemes, a plain pulmonic egressive /k/ (with two allophones [k] and [k^h]) and a glottalic egressive /k'/. The two phonemes contrast in almost all of their environments.

The next step would be to compare the distribution of Tojolabal [t'] with those of the two hypothesized allophones of /t/, [t] and [t^h]. All we can tell from these twenty words is that [t'], since it occurs finally in (3), probably constrasts with [t^h]. Similarly, [p] in (3) and [p'] in (11) seem to contrast in initial position. To carry out these comparisons systematically, however, we clearly need more data—much more data.

For a slightly different type of analytic problem, consider the twenty words below from the Koya dialect of Gondi, a Dravidian language spoken in India. The apical trill [r] and the apical tap [ɾ] have the same manner of articulation, as we saw in Chapter 2—namely, rapid and intermittent closure. The main difference between them is length (the trill is longer). The question is, do they belong to the same phoneme?

(1)	affection	pirti	(11)	in feather	girde
(2)	after, behind	peɾke	(12)	in path	arde
(3)	bamboos	veddurku	(13)	plowshare	karɾu
(4)	black pepper	miriyæ:ki	(14)	rupee	ɾupæ:y
(5)	both	iɾuvu:ɾu	(15)	sandal	eɾpu
(6)	car	ka:ɾu	(16)	servant	na:vukaɾ
(7)	complete	purti	(17)	son	marɾi
(8)	crazy	verɾi	(18)	water	e:ɾu
(9)	disease	ɾo:gæm	(19	weed	podeɾ
(10)	half	aɾa	(20)	wing	ɾekka

The first step is to see whether either of the phones in question has a restricted distribution. The trill seems to; it occurs only before other consonants. But the tap occurs in all major positions in the word: initially (9, 14, 20), finally (16, 19), intervocalically (4, 5, 6, 10, 18), medially before other consonants (2, 3, 15), and medially after another consonant—but only after [r] (8, 13, 17).

Since the trill occurs in only one of these positions, it can only contrast with the tap in this position, namely, before a consonant. We can therefore focus our attention on the words where one of the two phones occurs /__C (where the cover symbol C = any consonant). Note that if the tap and the trill contrast in this one position they must belong to separate phonemes in spite of the fact that the tap occurs in various other positions as well, because

only **one** position of contrast is needed to make a phonemic distinction. (In that case we would still suspect that [r] should belong in a phoneme together with some other allophone, because a whole phoneme with such a restricted distribution is very unlikely; still we can't group it with the tap if they contrast in that position.)

But do they contrast /__C ? Well, it looks that way as long as we state the environment as /__C. But the next step is to look moer closely at the nature of the following consonants: can we find a systematic difference between the kinds of consonants that follow [r], as opposed to the consonants that follow [ɾ]? Examination of the consonants shows that the trill precedes [t], [d], or [ɾ], while the tap precedes [k] or [p]. So the two phones never occur before the same consonant. But this isn't sufficient evidence for a pattern of complementary distribution, because all we have so far are two lists of following consonants, and a list is not a pattern. As we saw above with the Tojolabal data, when there are no minimal pairs we could, in principle, list every environment in which each phone occurs and claim those separate lists as evidence that the phones are allophones of the same phoneme. That would be a mistake! In order to demonstrate that we have a pattern of complementary distribution, we need to be able to make a **general** statement about the differing environments.

In the Tojolabal case we couldn't do that for the glottalized and nonglottalized stops, but we can do it for the Koya Gondi trill and tap: the trill precedes only apical consonants, while the tap precedes only nonapical consonants. We can therefore posit a tap phoneme /ɾ/ which is realized phonetically as a trill when it precedes only apical consonants (including the phoneme /r/ itself) and as a tap everywhere else. So, for instance, the phonemic representation of (17) 'son' will be /maɾri/, the phonemic representation of (1) 'affection' will be /piɾti/, and so forth.

As a final example in this section, let's look at some words from the Croatian dialect spoken in Orlec, a village on the island of Cres in the Adriatic Sea off the coast of Croatia. In this dialect, long vowels have either a rising tone (indicated by an acute accent, as in [á]) or a falling tone (indicated by a grave accent, as in [à]). Are these two tones phonemically distinct? That is, do they belong to two separate tone phonemes, or are they allophones of a single tone phoneme?

(1)	above	gó:re	(11)	nun	švò:ra
(2)	beans	fažò:l	(12)	of cauldrons	lavè:č
(3)	beehive	gù:l	(13)	of chopping-blocks	tà:k
(4)	below	dó:le	(14)	pull	tí:rat
(5)	deaf (definite)	glú:xi	(15)	rope	špà:x
(6)	ewe lamb	jà:ntsa	(16)	somewhere	né:gde
(7)	from below	zdò:la	(17)	sweat	pò:t
(8)	go	redú:	(18)	thousand	mijá:r
(9)	hare	zà:jóí	(19)	trunk	bagù:l
(10)	he spoke	govorí:l	(20)	with a woman	ženú:

As in the previous problems, we have no minimal pairs that would make a decision about the phonemic status of the two tones easy. We can find some distributional differences in the Orlec data: the rising tone does not occur in monosyllables, but the falling tone does (3, 9, 15, 17); and only the rising tone occurs on word-final long vowels (8, 20). Moreover, words (4) and (7), to judge by their meanings and by the fact that they share most of their segments, are variant forms of the same lexical item, 'below'.

However, in most environments both tones occur. In the initial syllable of two-syllable words we find both the rising tone (1, 4, 5, 14, 16) and the falling tone (6, 7, 11); and in the second syllable of two-syllable words, in words that end in a consonant, we find both the rising tone (10, 18) and the falling tone (2, 12, 19). Both tones occur on the same vowel: compare e.g. (1) and (11), (5) and (19). And both occur after the same consonant: compare (1) and (3), (13) and (14). In fact, no matter how far we look, we will not find any pattern of complementary distribution for the two tones. Therefore, since we cannot predict when each will occur, we must posit two separate tone phonemes, a rising tone /'/ and a falling tone /‘/. Actually, if we looked at moer Orlec vocabulary, we would find a few minimal pairs: compare, for instance, [já:ntsa] 'of a lamb' with [jà:ntsa] 'ewe-lamb'. But minimal pairs are never needed to establish a phonemic distinction; the lack of a pattern of complementary distribution between ['] and [‘] is enough to prove that they contrast.

3.2. Distinctive features

Let's go back to one of the phonological rules above for a moment—the one that specifies the aspiration of voiceless stops in Tojolabal:

stops → [+aspirated] /__#
[-voice]
[-glottalized]

The specification of single phonetic features, like [+aspirated], and groups of features, like [-voice], [-glottalized], is one of the phonologist's most important notational tools. In fact, fully formalized rules use **only** feature specifications—no terms like 'stop' or phoneme symbols like /t/, which we used in §3.1. Phonologists believe that, for purposes of writing formal rules, a language's phonemes can be most economically represented as bundles of **distinctive features**. The distinctive features of a language are those phonetic features, e.g. [voice] in English or [glottalized] in Tojolabal, that serve to differentiate the phonemes of the language from each other.

One reason why distinctive features are more economical phonological units than whole phonemes, for purposes of rule-writing, is that any language has fewer distinctive features than it has phonemes. You can see why this is true if you consider the following pairs of English phonemes:

/p/	/t/	/č/	/k/	/f/	/θ/	/s/	/š/
/b/	/d/	/ǰ/	/g/	/v/	/ð/	/z/	/ž/

Each pair differs in just one feature. This is the feature [voice], which has to do with whether vocal cord vibration is present or not during the pronunciation of the sound. The topmost member of each pair is voiceless, or [-voice] ('minus voice'); the lower member is voiced, or [+voice] ('plus voice'). If we use distinctive features to identify these sixteen English phonemes, we need only specify the place and manner of articulation for each pair—bilabial oral stop, apicoalveolar oral stop, alveopalatal affricate, and so forth—and then use the single feature [voice] to distinguish between the members of the eight pairs.

Distinctive features serve another important function: they facilitate the simplest and most elegant expression of phonological rules, because particular groups of distinctive features pick out **natural phonetic classes** of sounds. For instance, it turns out that we need only two features to specify the class of all obstruents, and using features in writing rules that apply to obstruents is therefore simpler than listing the classes of oral stops, affricates, and fricatives. Since many languages have phonological rules that affect only obstruents, the formal feature specification proves most useful.

In any given language, the **non**distinctive phonetic features will outnumber the set of distinctive features, because all languages have extensive allophonic variation in their phonemic systems. For example, the allophonic Tojolabal rule discussed above specifies an allophonic alternation: nonglottalized voiceless stops become [+aspirated] word-finally. But [aspirated] is not a **distinctive** feature in this language; as we discovered by carrying out a phonemic analysis of Tojolabal stop phones, the feature [aspirated] never distinguishes two phonemes.

On the contrary, aspiration is predictable wherever it occurs, namely, as an allophonic (or **subphonemic**) phonetic variant in wrod-final position.

Of course, there is nothing in the phonetic nature of aspiration that would prevent it from being phonemically relevant—distinctive—in some languages. It just happens not to be a distinctive feature in Tojolabal. In a language like Thai, however, [aspirated] is indeed a distinctive feature, because in Thai [k^h], for instance, contrasts with [k], so the two sounds belong to separate phonemes, /k^h/ and /k/.

In working out a complete set of distinctive features for a language's phonological system, we will of course restrict our feature inventory (by definition!) to those features which serve to distinguish the language's phonemes from one another. But when we write phonological rules to account for the various systematic phonetic distributions and phonological processes of that language, we will have to employ both distinctive and nondistinctive phonetic feature specifications. In other words, we will need to predict varying phonetic realizations—allophones—of the language's phonemes, and we'll need to use nondistinctive features to describe many phonetic realizations.

How do we go about finding an appropriate set of distinctive features for a language? The usual way is to consult a list of those features that are most often distinctive in languages, and to pick out as many of them as necessary (but **no more** than necessary) to distinguish all of the language's phonemes. We start with the most important features, the so-called **major class features,** because they are virtually universally distinctive in the world's languages. Then we proceed to place and manner features, and finally, if necessary, to less commonly distinctive features like [aspirated] and [alveolar] (vs. dental). If the list we consult has no feature to fit a distinction we need to make, then we might make use of a feature that isn't on the list. But we'd have to check carefully to make sure that the distinction in question can't be handled with the basic list of features , because a major goal is economy, which requires that we make all the necessary distinctions with the smallest possible set of features.

We are now ready to set out a basic list of commonly distinctive features. The list below might be termed "classical", containing features that have been in use at least since the 1970s; some of these have been abandoned or redefined in the last few decades, but for present purposes we needn't get into the controversies over the most appropriate feature sets.

Unfortunately, a list of distinctive features does not use all and only the articulatory phonetic category terms that you've learned from standard phonetic charts—stop, vocoid, velar, labial, and so forth. As you will see, however, the feature specifications can be combined to pick out such categories. And the use of the traditional phonetic category labels would be inefficient, sicne they are often quite redundant. For instance, we don't need two features [stop] and [fricative] to distinguish the class of stops from the class of fricatives; we need only one, [continuant], because stops are [-continuant] (the airstream is blocked completely

in the oral cavity), while fricatives are [+continuant] (the airstream continues on through the oral cavity).

Distinctive Features

A. Major class features:

- **[syllabic]:** [+syll] = functions as a vowel in a syllable, i.e. is the syllable's most sonorous segment; [-syll] = functions as a consonant in a syllable.
- **[consonantal]:** [+cons] = narrowed constriction in the oral cavity or pharynx—stops (except for [ʔ]), fricatives, affricates, nasals, and **liquids** (the lateral approximant [l], resonant trills, tap, and flap)l=; [-cons] = vocoids and the glottal stop [ʔ].
- **[sonorant]:** [-son] = obstruents, i.e. oral stops, fricatives, and affricates, and also the glottal sounds [ʔ] and [h]; [+son] = everything else, i.e. all resonant consonants and vowels—liquids, nasals, and vocoids. Most [+son] segments in all languages are voiced; [-son] segments are more likely to be voiceless.

B. Manner features:

- **[continuant]:** [+cont] = the airstream keeps moving through the oral cavity—fricatives, laterals, vocoids; [-cont] = complete blockage of the airstream in the vocal tract—nasal and oral stops; affricates; the glottal stop; and trills, tap, and flap (though some phonologists consider these liquids to be [+cont], since the closure is automatic and rapid).
- **[strident]:** [+strid] = noisier fricatives and affricates, including all sibilants and some other fricatives too, e.g. [f s š x̣ ʦ č] and their voiced counterparts; [-strid] = less noisy fricatives and affricates, e.g. [θ ç x] and their voiced counterparts. All plain (i.e. unaffricated) oral stops and all nonobstruents are also [-strid].
- **[delayed release]:** [+del.rel] = slow release = fricative release of an oral stopped consonant—affricates; [-del.rel] = everything else, including oral stops and fricatives.

- **[nasal]:** [+nas] = sounds pronounced with a lowered velum, most often [+sonorant] nasal stops and nasalized vocoids; [-nas] = everything else, i.e. oral sounds, i.e. sounds pronounced with the velum raised to close off the nasal passage.

C. Place of articulation features:

- **[anterior]:** [+ant] = pronounced in the oral cavity at a point on, or anterior to (farther forward in the mouth), the alveolar ridge—labials, dentals, alveolars; [-ant] = pronounced behind the alveolar ridge—alveopalatals, palatals, velars, uvulars, pharyngeals.
- **[coronal]:** [+cor]: blade of tongue is raised up out of neutral position—apical and laminal segments; [-cor] = all other lower articulators—labials, frontals, dorsals, and also [ʔ] and [h].
- **[back]:** [+back] = body of tongue moved back from neutral position: velars, uvulars, pharyngeals, back vowels, and [w] (but **not** [h ʔ]); [-back] = everything else.
- **[high]:** [+high] = body of tongue raised up out of neutral position—palatal and velar consonants, high vocoids such as [u i w y], palatalized consonants, and velarized consonants; [-high] = everything else.
- **[low]:** [+low] = body of tongue lowered below neutral position—low vowels and pharyngeal and pharyngealized consonants (but **not** [h ʔ], because the tongue body is not one of their articulators); [-low] = everything else.

D. Other segmental features:

- **[round]:** [+rnd] = pronounced with lip protrusion: labialized contoids and rounded vocoids, e.g. [k^{w}] w o u ü]; [-rnd] = everything else.
- **[voice]:** [+voice] = voiced = vocal cords in vibration; [-voice] = voiceless = no vocal cord vibration.
- **[long]:** relevant for both vowels and consonants.

- **[tense]:** [+tense] = pronounced with relatively greater tension of the vocal muscles. Occurs with both consonants and vowels, including, in some analyses of English, the long diphthongized Vs [i e o u] in *beat, bait, boot, boat*; [-tense] = lax—vocal muscles relatively more relaxed than with [+tense] segments.
- **[aspirated]:** used only with consonants, and usually with obstruents.
- **[glottalized]:** used mainly with consonants.

E. Suprasegmental (prosodic) features:

- **[stress]:** relevant only for whole syllables; usually marked in transcriptions over [+syllabic] segments, and thus used to distinguish stressed from unstressed vowels.
- **[HIGH]** = high tone (written in capital letters to avoid confusion with the tongue-body feature [high]).
- **[MID]:** mid tone.
- **[LOW]:** low tone.
- **[RISING]:** rising tone.
- **[FALLING]:** falling tone.

Tone features are rather controversial. The five tone features given here are in rather common usage.

[The chapter continues with sets of distinctive features for a few languages and then §3.3, Phonological Rules.]