Chapter Three Phonology

Steven Pinker, author of *The Language Instinct*, once pointed out that great strides in science often come about by devoting massive research efforts on isolated, apparently simple, yet representative phenomena that he called "model organisms". Linguistics is no different in this regard; just this kind of massive research effort on an isolated, apparently simple, yet representative phenomenon was carried out by Patricia Kuhl, a psycholinguistic researcher.¹ Kuhl's model-organism studies focused on the perception by children and adults of only two sounds, namely, [p^ha] and [b^ha].²

To appreciate the importance of Kuhl's findings, it is important first to understand a bit more about $[p^ha]$ and $[b^ha]$. When a native speaker of English makes these sounds, and other native speakers listen to them, the listeners are obviously aware that the two sounds differ. The difference comes about because voicing begins late in $[p^ha]$ and much earlier in $[b^ha]$; otherwise, the two sounds are identical. When native speakers produce these two sounds, one would thus think that they articulate the voicing-onset distinction rather carefully. In fact, when we record the production of $[p^ha]$ and $[b^ha]$ on a sound spectrograph, we find that the distinction made between these two sounds during articulation is anything but dramatic. Indeed, what we find instead is a kind of continuum, where the articulation of voicing onset varies anywhere between quite early to quite late. The surprise, then, is native speakers don't perceive this continuum when they listen to these sounds. Rather, what they hear is a categorical distinction: Sounds are either $[p^ha]$ or $[b^ha]$, not some mixed creature in between the two. In other words, even though non-human acoustic analysis reveals that the two sounds may not be particularly distinct at all, we hear them at being very distinct.

¹ Pinker's own detailed model-organism studies focused on morphology, specifically, the difference between regular and irregular verbs (e.g., *look-looked* vs. *go-went*). For a summary of some of the findings of Pinker and his colleagues, see Steven Pinker & Alan Prince, "Regular and Irregular Morphology and the Psychological Status of Rules of Grammar," *Proceedings of the Seventeenth Annual Meeting of the Berkeley Linguistics Society*, edited by L. A. Hutton & C. Johnson, pp. 230-251 (Berkeley, CA: Berkeley Linguistics Society, 1991).

² For a summary of Kuhl's findings on [pa] vs. [ba] as well as other model-organism areas, see Patricia Kuhl, "Perception, Cognition, and the Ontogenetic and Phylogenetic Emergence of Human Speech," *Plasticity of Development*, edited by S. Brauth, W. Hall & R. Dooling, pp. 73-106 (Cambridge, MA: MIT Press, 1991).

We call this perceptual classification of sounds by human ears *categorical perception*. Of course, categorical perception is not in the speaker's ears at all; it's in her mind/brain. In particular, it involves the way that native speakers' linguistic knowledge allows them to classify particular instances of sounds into one category or another. We refer to this knowledge as the speakers knowledge of the phonology of a language; the field of study known as *phonology* examines the patterning of human-language sounds into categories and the knowledge underlying this patterning of sounds.

In this chapter, we will only cover some introductory concepts in simple, linear phonology. We begin by applying labels to the categories that the native speaker's knowledge includes, here at the level of individual segments and syllables. Indeed, for much of our time on phonology, we will be learning by doing, specifically, by examining the language data in the relevant sections of Cowan & Rakušan. In addition, we will also have occasion to consider, if only briefly, some problems with phonological rules and what their relationship to one another might mean for a theory of language acquisition. What we will not cover is theoretical work that goes beyond seeing phonology as involving simple linear strings of perceived sounds.³

³ For such information, one can turn to more in-depth presentations such as found in Donna Jo Napoli's *Linguistics* (Oxford: Oxford University Press, 1996).

1. Basic Concepts

1.1 Contrasting sounds

When speakers of English hear sounds like the $[p^h]$ and $[b^h]$ of Kuhl's $[p^ha]$ vs. $[b^ha]$ experiments, they know intuitively that these two sounds are different. We can be more explicit about this knowledge by examining a pair of English words that *differ only* on the sounds $[p^h]$ and $[b^h]$. A good example of such a *minimal pair* would be $[p^hat]$ and $[b^hat]$, where the phonetic *environments* of the two sounds are identical: Both $[p^h]$ and $[b^h]$ are word-initial and followed by the sounds [at]. The fact that $[p^hat]$ and $[b^hat]$ have *different meanings* provides straightforward indication that these two sounds represent different sound classes for English native speakers. The technical terminology here is that $[p^h]$ and $[b^h]$ *contrast*; equivalent terminology is that the two sounds or the basic features of those sounds (here $[\pm voice]$) are *distinctive* or in *opposition*.

Note, of course, that locating contrasts as we did above generally involves sounds that are close to begin with. Thus, $[p^h]$ and $[b^h]$ are good model-organism examples for a more careful examination because they are relatively close (voiced bilabial stop vs. voiceless bilabial stop); for pairs of sounds that are wildly different to begin with (e.g., [b] vs. [v], or [?] vs. $[\theta]$), we would expect English (or any other language) to show contrasts. Even so, due to accidents of a language's historical development, it is not always easy to locate a minimal pair even for pairs of sounds that are close together. Consider, for example, another model-organism sound-pair of English: [š] and [ž]. Of course, it is easy to locate words that include these sounds: *sure*, *ash*, *fish*, *azure*, *beige*, *leisure*, and so forth. But trying to locating a true minimal pair for these two will strain one's imagination for hours on end. In such cases, we find ourselves with no choice but to rely *near minimal pairs*, where the meanings are different, but the phonetic environments of the two sounds are very close, though not identical. For [š] and [ž], one might thus locate *azure* vs. *assure*.

Consider the matter in a bit more detail. The sounds $[p^h]$ and $[b^h]$ are closely related, differing only on voicing, yet the minimal pair discussed above bears out what we already know, namely, that $[p^h]$ and $[b^h]$ belong to different sound categories. However, other pairs of sounds are also closely related, but they don't belong to different sound categories. Consider, for example, the so-called light 'L' and the dark 'L' of American English. We find these two sounds in words like *ball* and *live*, where the (dark) 'L' as in *ball* is articulated with the back of the tongue raised upwards towards the velum while the (light) 'L' in *live* is articulated with the back of the tongue in the lowered position. We

represent the dark variety as [] and the light variety as [l]. Note, though, that our intuitive knowledge of English tells us immediately that [l] and [] are really just slightly different varieties of exactly the same sound category: They're both "L's". We can also provide evidence for this intuition by using the same test that we used above, namely, by trying to locate a minimal pair (or a near minimal pair). If we were to locate a minimal pair or even a near minimal pair for [l] vs. [], we would have evidence that the two sounds are members of different sound categories, that is, that our intuitive knowledge was wrong. But, in fact, we can't find either one: There are no minimal pairs for [l] vs. [], nor are there any near minimal pairs. In other words, the lack of evidence indicating that [l] and [] contrast suggests that these two sounds are members of exactly the same category, thus confirming our intuition above.

1.2 Allophones and phonemes

Let's try to put some of this together. We've observed for English that pairs of sounds like [p^h] and [b^h] belong to different sound classes, but that pairs of sounds like [l] and [] belong to one and the same class of sounds. In linguistics, we have technical terminology that covers these ideas. Individual sounds (e.g., [p], [b], [l], [], etc) are known as *allophones*, and the mental sound classes to which these allophones belong are known as *phonemes*, instances of which are always written between slashes (i.e., not the brackets employed in the study of phonetics). For the model-organism examples we are considering, we can thus say that the allophones [p^h] and [b^h] belong to different phonemes, namely, /p/ and /b/, while [l] and [] are allophones of the very same phoneme, /l/. We can represent this visually in the following way:



The visual representation on the left above means that the sounds [1] and [] are different instances of the single phoneme /l/; the visual representations on the right mean that $[p^h]$ is an instance of the phoneme /b/ while $[b^h]$ is an instance of the phoneme /b/.

Finally, let's carry the understanding a little further by considering the phoneme /p/ again. Above we noted that it appears to have only one allophone, namely, $[p^h]$. Recall from Chapter 2, however, that English has two "P" sounds: [p] and $[p^h]$ (i.e., unaspirated and aspirated). Do these two sounds contrast? (That is, are they instances of different sound categories?) Or are they allophones of the single phoneme, /p/? (That is, are they just two instances of the same sound category?) In fact, our intuition as native speakers of English tells us immediately that [p] and $[p^h]$ are actually just two varieties of the same sound, that is, that they are allophones of /p/. (Concrete evidence for this intuition would be the complete absence in English of any minimal pairs differing on [p] and $[p^h]$.) In other words, rather than the visual presentation shown in (ii) above for /p/, we find the one shown below, which indicates that the phoneme /p/ as two allophones in English, namely, [p] and $[p^h]$.



1.3 Complementary distribution or free variation?

We have seen that [b] and [p] are instances of the different phonemes /b/ and /p/. By contrast, the sounds [p] and $[p^h]$ are both allophones of /p/. But does this mean that [p] and $[p^h]$ aren't used differently in some way? In fact, when we look carefully, we discover something interesting about the distribution of [p] and $[p^h]$ in English. Consider the listings below:

[p ^h]	[p]
port	sport
peace	soup
append	apple

By inspecting the two listings above, we discover the condition under which the aspirated variety of /p/ appears: Only when /p/ appears as the first sound in a stressed syllable does aspiration show up. In all other positions—and this will turn out to be the larger number of positions—we find the usual, unaspirated variety of /p/. More generally, when we find that allophones of a single phoneme appear in different environments, we speak of their being in *complementary distribution*. The allophone that appears in the larger number of positions—as in the case of the unaspirated variety of /p/—is then said to meet the *elsewhere* condition. We can thus add more information to the visual representation we made before for [p] and [p^h].



Allophones of a single phoneme in complementary distribution are thus ones where the phonetic environments are not the same. The allophone that appears in the greatest number of environments meets the elsewhere condition.

But not all allophones of a phoneme appear in complementary distribution. Sometimes we observe allophones in exactly the same environment. A good example of this phenomenon involves, once again, our model-organism phoneme /p/. Before we noted that this phoneme has two allophones, the unaspirated [p] and the aspirated $[p^h]$. In both of these sounds, the blockage of the airflow is released before the following sound. There is, however, another allophone of the phoneme /p/ in English, however. This one is the *unreleased* variety, which we represent with a diacritic: $[p^n]$. This allophone of /p/ appears when we do not release the blockage of the airflow (i.e., lips not open) at the end of its articulation. Consider the following:

a. heap	[hiyp]] or [hiyp]
b. rope	[rowp [¬]] or [rowp]
c. laptop	[læp [¬] tap]
d. popcorn	[p ^h ap [¬] krn]
e. hippy	[hipiy] (but not [hip'iy])

As these data indicate, $[p^{\neg}]$ appears at the end of words, including words that are used together with other words to form what we call *compounds*. *Crucial, however, are the examples in (a) and (b)* above, which show that the allophones [p] and $[p^{\neg}]$ can also appear in exactly the same environment. When allophones of a single phoneme appear in exactly the same environment in this way, we speak of *overlapping distribution* (as opposed to complementary distribution), and we conclude that these allophones are in *free variation*.

Our model-organism approach, concentrating most of our attention on the American-English 'P' sound, has thus yielded benefits. We've found that $[p^h]$ contrasts with $[b^h]$, as shown by the minimal pair *pat* vs. *bat*. We've concluded that $[p^h]$ is an allophone of the phoneme /p/, while $[b^h]$ is an allophone of some other phoneme. Further, we've found no minimal pairs for the phones [p] and $[p^h]$, but that they don't appear in the same phonetic environment. We've thus concluded that [p] and $[p^h]$ are allophones of the phoneme /p/ in complementary distribution. However, turning our attention to [p] vs. $[p^n]$, we found that their environments can be identical, that is, that their distribution overlaps. We've concluded in this case that [p] and $[p^n]$ are allophones of the same phoneme /p/, but in this case they are in free variation.

1.4 Extending to other languages

So far, we've limited our model-organism examination of the 'P' sound to English. In fact, by turning our attention to other languages, we can discover even more. Consider Sindhi, a language spoken in parts of India and Pakistan. The question we will ask here is whether the allophones [p] and [p^h] and their near relative [b] are distributed in the same way in Sindhi that they are in English. Just to be sure, let's repeat their English distribution, shown below:



In English, then, [p] and $[p^h]$ are allophones of /p/ while [b] is an allophone of the different phoneme [b]. We know this to be true of [p] vs. [b] in English because we can find minimal pairs to differentiate [p] from [b] (e.g., *pat* vs. *bat*). But the fact that there are no minimal pairs or near minimal pairs for [p] vs. $[p^h]$ suggests that they are allophones of the same phoneme.

Now consider Sindhi. In particular, in the Sindhi data below, we try to locate minimal pairs for the closely related sounds in the sound-triplet [p] vs. $[p^h]$ vs. [b]. Because it's a triplet, we'll need to proceed piecemeal: [p] vs. $[p^h]$; and [p] vs. [b]; and $[p^h]$ vs. [b]. (Recall that being a minimal pair requires that the two sounds appear in the same phonetic environment, but that the words in which they appear must have different meanings.)

a. [p̈nu]	leaf
b. [p ^ħ nu]	snake hood
c. [b̈́nu]	forest

What do these data reveal? First, we observe a minimal pair for [p] vs. $[p^h]$ in examples (a) and (b). This observation means that [p] and $[p^h]$ must be allophones of different phonemes in Sindhi—quite a contrast from English. Second, we observe a minimal pair for [p] vs. [b] in examples (a) and (c). This observation means that, as in English, [p] and [b] are allophones of different phonemes. Finally,

for the pair $[p^h]$ vs. [b], we find a third minimal pair in examples (b) and (c). We conclude, therefore, that $[p^h]$ and [b] are allophones of different phonemes, again as in English. The general picture that emerges from these observations is something like the situation shown below. As we can see by comparing the visual representations for English above and Sindhi below, these sounds pattern rather differently in the two languages.

Sindhi: phoneme	/p/	phoneme	$/p^{h}/$	phoneme	/b/
allophone	[p]	allophone	$[p^h]$	allophone	[b]

Of course, one could say that the [p] vs. $[p^h]$ vs. [b] comparison of English and Sindhi just shows a limited and idiosyncratic curiosity, perhaps a quirk of one or the other of the two languages. But if we really buy into our model-organism approach, then the insight to be gained from the comparison of English and Sindhi is much deeper than just an idle curiosity. And, indeed, the benefit *is* more: For a set of related sounds like [p] and $[p^h]$ and [b], we find that a given language may represent them as allophones of the same phoneme or as allophones of different phonemes. Indeed, if we were to examine other languages, too, we would also find that these sounds may be allophones of the same phoneme in complementary distribution, or allophones of the same phoneme in free variation or allophones of different phonemes.

1.5 Extending beyond model organisms

As the work of Steven Pinker and Patricia Kuhl and their colleagues has shown, the real payoff of the model-organism approach is not just to discover something interesting about an isolated phenomenon, but to discover something far broader in scope by generalizing from findings on that phenomenon. Above we caught a glimpse of this type of generalizing with our comparison of our model-organism sounds [p] and [p^h] and [b] in English and Sindhi. Note, though, that we are still limited in our generalizations to cousins of the 'P' sound. As we will discover as we work with more of English and with other languages, the same general ground plan we have found for our model-organism sounds also applies to other groups of sounds: Closely related sounds may be assigned to the same or to different phonemes; allophones of a single phoneme may be found to be in complementary distribution or in free variation. It should perhaps also come as no surprise that natural classes play a major defining role in defining allophonic variation, particularly for allophones of a single phoneme in complementary distribution.

1.6 Phonological rules

In linguistics, it is common to think that one's linguistic knowledge is comprised of rules of some type. Our knowledge of phonology is no exception in this regard. Such rules are relatively easy to understand, at least in terms of their form. Their general form is as follows:

General form: $/A/ \rightarrow [B] / X _ Y$

The reading of this general form is as follows: A particular phoneme "/A/" is expressed as " \rightarrow " an allophone "[B]" if "/" that allophone appears "_" in the environment after "X" and before "Y". Of course, not all rules will require both "X" and "Y" as conditions on the environment (and, as we shall see shortly, elsewhere rules require no statement of the conditioning environment at all). In addition, when a conditioning environment involves the beginnings or ends of syllables, we indicate this environmental condition with the symbol " σ "; if the environment involves the beginnings or ends of words, we employ the symbol "#" to indicate this environmental condition.

Now consider an actual example of a rule. For this example, let's examine again our visual representation of the two allophones of English /p/ above, the relevant portion of which is repeated below for convenience.



Inspection of the representation above shows that the phoneme /p/ is realized as the sound [p] unless it is the first sound in a stressed syllable. We can formulate this statement in terms of a rule as follows:

Model rule: $/p/ \rightarrow [p^h] / \sigma_{\hat{v}}$

This rule would read as follows: "The phoneme /p/ is realized as the allophone [p^h] when it is at the beginning of a stressed syllable." Note, though, that the model rule above does not include a way to

produce the allophone [p], which appears in the elsewhere condition. For this, we expand the statement of the rule above to include [p]:

Model Rule: $/p/ \rightarrow [p^h] / \sigma_{\hat{v}}$ $/p/ \rightarrow [p] / elsewhere$

As we work through model problems later in the chapter, we will find occasion to expand somewhat on how to write such rules.

2. Working with Linguistic Data

Before turning to examinations of data sets, it is well worth while to consider some basic working procedures that will help to extract the relevant types of information from them. The typical problem involves determining, for a given set of data, responses to the following:

- (a) Are the sounds in question allophones of different phonemes or allophones of the same phoneme? What evidence do you have?
- (b) If the sounds are allophones of the same phoneme, then are they in complementary distribution or in free variation? What evidence do you have?
- (c) If the sounds are in complementary distribution, write phonological rules.

To work through determining such responses, we provide first a set of procedures, then an example problem with which we illustrate these procedures.

Procedure

- 1. The problem will ask you to focus your attention on certain focus sounds. Before you do anything else, ask yourself a simple question: Are these sounds phonetically similar?
 - a. If they are significantly different (e.g., [?] vs. [iy]), then they are allophones of different phonemes. Provide your answer and explain the great difference as reason for your answer.
 - a. If the sounds are somewhat similar, then continue by going through the data and locating every instance of the sounds. Go on to procedure 2 below.
- 2. At this point, look for any minimal pairs in the data. These pairs will differ only on the focus sounds, but the words will have different meanings.
 - a. If you find any minimal pairs, you've got proof that the sounds are allophones of different phonemes. Provide your answer and cite the minimal pairs as reason for your answer.
 - b. If you find any pairs where the phonetic environments are identical, but so are the meanings, then you've got allophones of the same phoneme in free variation. Provide your answer and provide the pairs as proof. (These are not minimal pairs since the meanings would be the same.)
- 3. If you haven't located an answer with procedures 1 or 2 above, then look carefully at the phonetic environments of the sounds. Make lists of data to indicate the environments of focus sounds.
 - a. If the sounds occur in the same phonetic environment, then you've got allophones of different phonemes. Historical accident (or poor data gathering on the part of the linguist) made it impossible for you to find minimal pairs, but you might be able to locate some near minimal pairs. State your answer and provide the near minimal pairs as proof.
 - b. If the sounds occur in different phonetic environments, then you've got allophones of the same phoneme in complementary distribution. State your answer and provide your reasoning. Go on to procedure 4 below.
- 4. Examine the environments and use natural classes to determine the nature of the rules that govern the complementarity. Use the sound with the least restrictions on occurrence (i.e., the one that will have the *elsewhere* condition) as the basic phoneme. Write rules following the general form discussed earlier in this chapter.

To see how these procedures are employed, consider the following, model problem:

2.1 Model Problem #1

Tojolabal (**Mexico**). Consider the sounds [t^h] and [t] and determine whether they are allophones of the same phoneme, or represent two different phonemes. (For your information, the sound [t'] is glottalized and therefore different from both [t^h] and [t].) If the sounds are allophones of the same phoneme, determine whether they are in free variation or complementary distribution. If they are in complementary distribution, state rules. In any case, state the evidence that supports your analysis.

a. čitam	pig	b. makton	a patch
c. čatat ^h	kind of plant	d. mut ^h	chicken
e. potoť	kind of plant	f. nahat ^h	long
g. tinan	upside down	h. ?inat ^h	seed

Now we follow the procedures step by step to examine the problem above:

- 1., 1a., 1b. The sounds [t] and [t^h] are quite close, one being the aspirated version of the other. Therefore, it would premature to conclude, prior to the rest of the analysis, that they are allophones of different phonemes.
- 2., 2a., 2b. An examination of the data reveals no minimal pairs and no pairs in which the two sounds freely occur in the same word. Because of this, it would be wrong to conclude that they are allophones of different phonemes or allophones of the same phoneme in free variation.
- 3. Prior to dealing with 3a. or 3b., make a listing of the sounds:

<u>[t]</u>	[<u>t</u> ^h]
[čitam]	[čatat ^h]*
[makton]	[mut ^h]
[potot']	[nahat ^h]
[tinan]	[ʔinat ^h]
[čatat ^h]*	

*We've listed [čatat^h] twice because it contains both [t] and [t^h].

- 3a. and 3b. An examination of the data in the two lists above shows that [t^h] and [t] have different environments: [t^h] only appears in word-final position. *One can conclude that* [t^h] and [t] are allophones of the same phoneme in complementary distribution. As reason, explain that [t^h] only appears in word-final position while [t] appears elsewhere. Provide at least one example of each.
- 4. Since these are allophones of the same phoneme in complementary distribution, one needs to write rules for their occurrence. We already know that [t^h] has the more restricted distribution (word-final only), so use [t] as the phoneme. The rules must be of the general form:

 $/A/ \rightarrow [B] / X _ Y$

The symbol for the beginning or end of a word is #. The two rules regulating the occurrence of [t] and [t^h] in Tojolabal are therefore the following:

 $/t/ \rightarrow [t^{h}] / _#$ $/t/ \rightarrow [t] / elsewhere$

We now turn to a second model problem, one that will require a somewhat more complex rule.

2.2 Model Problem #2

Mokilese (Austronesian language spoken in South Pacific): Consider the vowels [i] vs. [i] and [u] vs. [u] in the following data from Mokilese and determine whether they are allophones of the same phoneme, or represent two different phonemes. If the sounds are allophones of the same phoneme, determine whether they are in free variation or complementary distribution. If they are in complementary distribution, state rules. In any case, state the evidence that supports your analysis. (Note: the diacritic [] indicates voiceless.)

1. [pisan]	full of leaves	2. [tupukta]	bought
3. [uduk]	flesh	4. [kaskas]	to throw
5. [puko]	basket	6. [poki]	to strike (something)
7. [pil]	water	8. [kisa]	we two
9. [apid]	outrigger support	10. [supwo]	firewood
11. [kamwəkiti]	to move	12. [ludʒuk]	to tackle

Again, we follow the procedures step by step to come to a solution:

- 1., 1a., 1b.: The focus sounds [i] and [j] are closely related, and so are the sounds [u] and [u]. As a result, it would be wrong to conclude at this point either that the sounds [i] and [j] are allophones of different phonemes, or that the sounds [u] and [u] are allophones of different phonemes.
- 2., 2a., 2b.: An examination of the data reveals no minimal pairs for either [i] vs. [i] or [u] vs. [u]. The inspection also reveals no pairs in which the two sounds (either [i] vs. [i] or [u] vs. [u]) freely occur in the same word. Because of this, it would be wrong to conclude that the sound pairs are allophones of different phonemes or allophones of the same phoneme in free variation.

3. Before going on to 3a. or 3b., make a listing of the focus sounds. In this case, we require a double listing since we are dealing with two pairs: [i] vs. [i] and [u] vs. [u].

[i] versus	[i]	[u] versus	[ų]
[poki]	[pisan]	[uduk]	[puko]
[pil]	[kisa]	[ludʒuk]	[süpwo]
[apid]	[kamwəkiti]	[tupukta]	[kamwəkiti]

- 3a. and 3b. Examine the two pairs of lists one at a time. Comparing [i] and [i], we find that they have different environments: [i] only appears between voiceless consonants. The appropriate conclusion is that [i] and [i] are allophones of the same phoneme in complementary distribution. To support this conclusion, we would need to provide examples. In fact, by examining [u] vs. [u], we find a very similar environmental condition: [u] only appears between voiceless consonants. The conclusion is thus similar: [u] and [u] are allophones of the same phoneme in complementary distribution.
- 4. Since the two pairs of sounds are both allophones of the same phoneme in complementary distribution, we need to write rules for their occurrence. Noting that the voiceless varieties of the sounds have the more restricted environments, we could write two different sets of rules, as below. (Note that we use "C" to refer to "consonant".)

i. For [u] vs. [u]

$$/u/ \rightarrow [u] / C _ C$$

[-voice] [-voice]
 $/u/ \rightarrow [u] / elsewhere$

ii. For [i] vs. [i]

$$(i/ \rightarrow [i]) / C _ C$$

[-voice] [-voice]
 $(i/ \rightarrow [i]) / elsewhere$

The problem with writing two sets of rules like those above is that this approach misses the generalization that the same changes seem to be happening twice. A better apprach would thus be to figure out how we could capture all of the facts in a single set of rules. In fact, if we look at the two phonemes, /i/ and /u/,we discover that they fall into a natural class: They are both high vowels. Furthermore, the change that affects these two vowels is also common: voiced to voiceless. We can combine all of this information—and thereby capture the generalizations—in a single set of rules. (Note that we use "C" to refer to "consonant" and "V" to refer to "vowel".)

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/V/ \rightarrow [V] / C _ C
[high] [-voice] [-voice] [-voice]
[+voice]
/V/ \rightarrow [V] / elsewhere
[high] [+voice]
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[+voice]

3. Suprasegmental Phonology: The Syllable

In our study of phonetics in Chapter Two, we examined properties that go beyond the level of individual segments. It should come as no surprise that such properties obtain as well in phonology. In this chapter, we concentrate only on the structure of the *syllable*. In order to do so, however, we must first take a look at the (linear) sequences of sounds that are allowed in any given language, that is, at *phonotactic constraints*. Only then will we be able to examine the structure of syllables profitably.

3.1 Phonotactic constraints

When we look at words in English, we discover that the consonant sounds that appear at the beginning of the word are not drawn from the full set of possible English consonant sounds. Hence, there are no English words that begin with, for example, the consonant sequence [gsd]. In fact, a bit of analysis reveals that the longest sequence of consonants in English is three. In addition, even when more than one licit consonant is used at the beginnings of words, these consonants must be in a particular order. Thus, English words may begin, for instance, with the consonant sequences [sp] or [spr] (e.g., [spɛl], [sprey]), but they may not begin with the sequences [ps] or [rps].Words that are licit in a given language will thus always follow the relevant constraints on initial sequences of

sounds. In fact, it is not just word beginnings that follow these constraints; it is the beginning of every syllable that follows these constraints. (The beginning of every new word is also the beginning of a new syllable, but the beginning of every syllable isn't necessarily the beginning of a new word.) Such constraints on licit sequences are known in linguistics as phonotactic constraints.

Consider the phonotactic constraints operating in English in a bit more detail. The minimum number of consonants at the beginnings of words is, of course, zero. We thus have licit, free-standing words like *on*, *at*, *art*, and *open* as well as licit affixes like *un*- and *-able*. When the syllable begins with a single consonant, a good deal of variety is allowed in English, as one can discover by creating simple words like *bad*, *cat*, *dad*, *fad*, *gad*, *had*, *jade*, etc. As already noted above, the maximum number of licit consonants is three, and when the number is greater than one, then the order of consonants is important. The left-to-right ordering possibilities for English syllables that begin with three consonants are shown from top to bottom in the figure below, which indicates the beginning of the syllable at the top with the syllable symbol " σ ".



According to the figure above, licit syllable-initial three-consonant sequences in English should include [spl], [spr], [spw], [spy], [stl], [str], [stw], [sty], and so forth. (Keep in mind that we are *not* talking about the spellings of syllable beginnings here; rather, the predictions above refer to pronunciations.) Note, too, that a generalization also emerges: If a syllable begins with three consonants, then those consonants are [s] + [voiceless stop] + [liquid]/ [glide].

As already noted, some sequences are disallowed in principle as possible syllable beginnings. Sequences that fall into this type are known as *systematic gaps*. On other occasions, we may find that the native speaker's knowledge does not include words with syllables that appear otherwise to be permitted. It is, for instance, hard to come up with a word that begins with the sequence [pw]. Such absences are the result of personal or historical accident: Perhaps the speaker never learned a word with the missing sequence, or perhaps the language had a word with the missing sequences, but the

word was lost. Interestingly, when new words are added to the language (through coining, borrowing, etc.), they may well fill in these *accidental gaps*. For the otherwise licit beginning [pw], for example, we find the borrowed word *pueblo*, [pwɛblow].

Phonotactic constraints are universal, but there are differences among particular languages on what comprises these constraints. For instance, while English allows up to three syllable-initial consonants, the Hawai'ian language limits this sequence to one consonant. Moreover, as explained above, there are constraints on which consonants can appear—and in which order, when more than one are involved. Hence, while English disallows the sequences [pt] and [fs1], Russian allows both.

3.2 Syllabification

Asked to divide most words into syllables, native speakers don't have much trouble: The word *unable* divides easily into $[\Lambda n]$ [ey] [b]]; for reasons that most speakers are not aware of, it seems unreasonable to divide *unable* into $[\Lambda]$ [ney] [b]] or $[\Lambda ney]$ [b]]. Given other words to divide up, however, speakers become somewhat less secure. Does *extradite* divide into [ϵ ks] [tr Λ] [dayt], or does it divide into [ϵ k] [str Λ] [dayt]? Note that both divisions follow the phonotactic constraints of English.

For our purposes (i.e., discovering something about the structure of human languages), we can solve ambiguities like the one presented in words like *extradite* by learning something about the structure of syllables themselves. Syllables are comprised of three elements: an *onset*, a *nucleus* and a *coda*. As the name implies, the onset includes those consonants at the beginning of the syllable. The nucleus, typically a vowel (sometimes a syllablic consonant, indicated with the diactitic []), is the middle of the syllable, and the coda is the end. Interestingly, the only obligatory part is the nucleus, as shown by existence of licit words like *a* (e.g., <u>*a*</u> book) or *I* (e.g., <u>*I*</u> need *a* bath).

We think of syllables as having a hierarchical representation like the one shown in the figure below.



In the representation above, the complete syllable is indicated with the syllable symbol " σ " at the top. The material under "A" is the onset of the syllable; the material under "C" is the nucleus; and the material under "D" is the coda. The nucleus and the coda are combined together under "B"; this segment is known as the *rhyme*. Using the abbreviations O(nset), R(hyme), N(ucleus) and C(oda) along with the syllable symbol " σ ", we can thus reformulate the representation above in the way shown below.



Given this much, we can proceed to establish syllable representations for some simple examples like [hæt] (*hat*) and [strayk] (*strike*).







Distilling somewhat from the representations above, we thus come up with the following procedure to establish syllable structure:

Procedure

- 1. Because the nucleus is the only obligatory constituent of the syllable, write the nucleus and N(ucleus). Then draw in a line up to the R(hyme) and another line from R up to the syllable symbol, " σ ".
- 2. Always do the onset before you do the coda. For this, you include as the onset all of the consonants to the left of the nucleus that are allowed under the phonotactic constraints of the language in question. For these consonants, draw the line up to O(nset) and from O up to σ .
- 3. Any remaining consonants to the right of the nucleus are included in the C(oda). Include these consonants in your representation, draw the line up to C, and connect C to R.
- 4. For multi-syllabic words, connect all syllables together to form a word, symbolized by "Wd".

Using the procedure above, it is now possible to come up with an unambiguous syllabification for word like [ɛkstrʌdayt] *extradite*. In such cases, where there is more than one syllable, we construct all three syllables at the same time:

1. Establish nucleii and draw in N, R, and σ :



2. The next step is to include as the O(nset) all of the consonants to the left of each nucleus that are allowed under the phonotactic constraints of English. The first nucleus has no consonants to its left, so we do not include an onset for this for this syllable. The second nucleus has the sequence [kstr] to its left. Of this sequence, the maximum allowed under English phonotactic constraints is [str]. We thus include [str] as the onset of the second syllable. The third nucleus includes only [d] to its left, and this single consonant is allowed under the constraints for English, so [d] is included as the onset for the third syllable. Putting this information together, we build the representation below:



3. After establishing the O(nsets), we include the remaining consonants to the right of each nucleus as the C(oda) of that nucleus. We then draw in the relevant structure. Note that the presence of [str] in the onset of the second nucleus leaves only [k] as the coda of the first nucleus. Likewise, the presence of [d] in the onset of the third nucleus leaves no consonants in the coda of the second nucleus:





4. The final step is to connect the syllables together to form a word, "Wd".

Note that we now have an unambiguous answer to the question we posed earlier: Does *extradite* divide into [ϵ ks] [trA] [dayt], or does it divide into [ϵ k] [strA] [dayt]? The answer provided by applying the syllabification procedure to this word reveals that it syllabifies as [ϵ k] [strA] [dayt].

4. Whither Phonology? Rules and Derivations

So far, we've proposed that the native speaker's implicit phonological knowledge is comprised of rules that express phonemes as particular allophones. (Hence, the native speaker of English would have implicit knowledge of the rule $/p/ \rightarrow [p^h] / \sigma_v$, which expresses the phoneme /p/ as the allophone $[p^h]$ when it is in syllable-initial position.) Textbook presentations like the earlier parts of this chapter along with highly focused exercises like those at the end of this chapter are somewhat misleading, however, because they tend to underestimate the complexity of such rules and their application. The problem is not only that the native speaker's knowledge of phonology would comprise a good number of rules, but also that these rules would potentially have to apply in an order that would have to be stipulated (i.e., that they would not follow automatically from the very nature of the rules).

To see this problem, consider again the English rule $/p/ \rightarrow [p^h] / \sigma_v$. What must the speaker know implicitly in order to apply this rule? The answer is in the rule itself: The speaker must have implicit knowledge of English syllabification before this rule can be applied.⁴ Perhaps an even more telling example involves the English word *police*, often pronounced in informal speech as [pliys]. Tracing the *derivation* of this word, we start with an *underlying representation (UR)*—the form that appears before the application of any rules. The UR of *police* would be somewhat like the one shown below. (The presence of the symbols # around the UR indicate word boundaries.)

UR: #pliys#

Two rules must be applied to this UR, one to delete the schwa and the other to devoice /l/.

If we study the conditions on devoicing /l/ (i.e., liquid devoicing), we discover that rule involved here applies only when the liquid is preceded by a voiceless consonant. A possible rule for liquid devoicing would thus be the following (for convenience of presentation, the *otherwise* rule is not included).

Liquid Devoicing



What about the other rule, schwa deletion? As the example of *police* illustrates, the deletion of schwa seems to appear in an unstressed syllable when the onset is a voiceless stop consonant. The following rule might be said to represent this condition:

⁴ Here's a thought teaser: Imagine a case of language impairment that affected (i.e., destroyed) only knowledge of syllabification. What would this unfortunate person's aspiration look like?

Schwa Deletion

 $| \partial | \rightarrow \emptyset / \sigma C_{-}$ [-voice] [+stop]

So now we have two rules, liquid devoicing and schwa deletion, both of which must apply to derive the word [pliys]. Note, however, that they must apply in a particular order. Consider both orders of application, that is, liquid devoicing and then schwa deletion, and schwa deletion and then liquid devoicing:

Schwa deletion, then liquid devoicing		Liquid devoicing, then schwa deletion		
UR:	#pəliys#	UR:	#pəliys#	
schwa deletion:	#pliys#	liquid devoicing:	CAN'T APPLY!!!	
liquid devoicing:	#pliys#	schwa deletion:	#pliys#	

The derivation shown on the left seems to work fine. Schwa deletion applies, and because of its application, the liquid is adjacent to /p/. This creates the context for the application of liquid devoicing, which requires a voiceless stop to be adjacent to the left. When one rule applies to create the context necessary for some other rule, we speak of a *feeding relationship*, where the output of one rule acts as the input to the next rule. Crucially, note that the opposite application order (i.e., liquid devoicing, then schwa deletion) *doesn't* work because the context for liquid devoicing is not present. In other words, the application order liquid devoicing, then schwa deletion say [pliys], that is, without devoicing the liquid.

The existence of feeding relationships like the one we observed above seems to suggest that rules might just have to be ordered with respect to one another, a case of out-and-out stipulation in the grammar. We can, however, get around the necessity of such a stipulated *extrinsic rule ordering* in this case with some special moves. Suppose that we require that every phonological rule apply whenever it can. In other words, if the context for a particular rule exists, then the rule has no choice but to apply immediately. We might call such a scenario *intrinsic rule ordering*, that is, where a particular order in the application of rules arises because of the nature of the rules themselves plus the requirement that they apply immediately if their conditions are met. Applying intrinsic rule ordering to case of *police* above, we would discover the following:

Schwa deletion, then liquid devoicing because of free order application

UR:#pəliys#schwa deletion:#pliys#Schwa deletion applies immediately since the rule's context is met in UR.liquid devoicing:#pliys#Liquid devoicing now applies immediately because its context is now present.

As the representation indicates, schwa deletion has no choice but to apply first because its context is present in the Underlying Representation (UR). And because schwa deletion creates the relevant context for the liquid devoicing rule, liquid devoicing has no choice but to apply immediately after schwa deletion.

By having rules apply whenever they can immediately (i.e., intrinsic rule ordering), we appear to have gotten around the prospect of extrinsic rule ordering. Alas, on this view of phonology, natural languages aren't quite that nice, for there is evidence to indicate that extrinsic rule ordering would also have to be part of human-language knowledge of phonology.

As an instance of extrinsic rule ordering, consider so-called Canadian Raising (examined in Exercise 7 at the end of this chapter). There we find that this type of vowel raising appears just when the following consonant is voiceless. Hence, Peter Jennings (a Canadian) uses the raised vowel [Ay]in *write* to say [rAyt] and the unraised [ay] in *ride* to say [rayd]. But what about a word like *writer*, transcribed with the flap as [rayDr]? What has happened here is that the underlying voiceless phoneme /t/ has been realized as the voiced flap [D]. Suppose we call these two rules (i) Canadian raising and (ii) flapping. Now consider two possible derivations of *writer*, one with Canadian raising and then flapping, and the other with flapping and then Canadian raising. The presentation below is simplified in that we exclude the derivational steps associated with the syllabic consonant [r]. In addition, we also include a final line in the derivation, *Phonetic Representation (PR)*, which expresses the form that results from the application of whatever rules are involved.

Canadian raising and then flapping		Flapping and then Canadian raising		
UR:	#raytr#	UR:	#raytr#	
C. vowel raising:	#rʌytṛ#	flapping:	#rayDr#	
flapping:	#rлyDr#	C. vowel raising:	CAN'T APPLY!!!	
PR:	#rлyDr#	PR:	#rayDr#	

At this point, we only lack one bit of information, and it is crucial: Those who speak this variety of English (e.g., Canadians) produce $[r_AyDr]$, not [rayDr]. In other words, the derivation that works

(i.e., mirrors what these speakers actually do) is the one on the left.

We suggested above that the only way to make sure that the rules in this example apply in the proper order is through brute-force extrinsic rule ordering. It is thus important to understand why intrinsic rule ordering can't and won't work here. Recall that intrinsic ordering involves the claim that rules will apply whenever they can immediately. The problem starts with the UR of *writer*, which includes the contexts for both flapping and Canadian vowel raising. Since the two rules can't apply simultaneously, we find random choice on which applies first: either flapping or Canadian vowel raising. If Canadian vowel raising applies first, then all is fine. Note, though, that if flapping applies first—we have no way at hand to stop it from applying first—then its application effectively destroys the context for the application of Canadian raising. More generally, when either of two rules could apply to some UR and when the application of one of the two happens to remove the context for the application of the other, we have no choice but to stipulate, brute force, that the grammar must apply the one rule before it applies the other. In other words, we have no choice but to assume extrinsic rule ordering.

The general picture of phonological knowledge presented in this chapter includes rules that may apply either via intrinsic ordering or via extrinsic ordering.⁵ Research since this general view was introduced in the 1960s has located several problems with this view, most associated with extrinsic rule ordering. One of the problems is that one can find evidence for two different orderings of the same set of rules within a single language—a situation that is impossible under the general view we reviewed above.

There have been several proposals to get around the problems created by this model of phonological knowledge. At least one proposal represents not much more than a slight addition to the general model presented above. In effect, when either of two rules could apply to some UR (as in our example above), then the more specific rule always applies first. (Whether this alteration would solve all of the problems with extrinsic ordering is debatable.) Responding to the problems with the model above, other researchers dealing with phonological knowledge have gone back to the drawing board to create wholly new views, ones that, for example, might eschew entirely the general rules (and their orderings) that were presented in this chapter. For this type of more in-depth discussion of phonological knowledge, one might turn to more in-depth treatments like those in Napoli's

⁵ This general picture thus follows, in broad strokes, the view of phonology proposed by Noam Chomsky & Morris Halle in *The Sound Pattern of English* (New York: Harper & Row, 1968).

Linguistics (see footnote 3) or Philip Carr's Phonology (New York: St. Martin's Press, 1993).

5. A Final Word

Studying phonological knowledge, it is somewhat easy to lose sight of whose knowledge we are talking about, namely, the phonological knowledge of native speakers of a language. Indeed, it is worthwhile to think about these very people in some detail.

First of all, we are speaking of the phonological knowledge of particular *speech communities* of native speakers. Thus, for English, we certainly would not want to claim that every native speaker of the language is a member of the same speech community. After all, as we have observed, native speakers of English from the northern parts of North America have a different way of articulating vowels than other native speakers. Further, speakers of English who grew up in some parts⁶ of Boston have slightly different phonological knowledge from those who grew up in other parts of the city (as well as from those who grew up anywhere outside of Boston); those who grew up in the South Texas speech community have slightly different phonological knowledge from the speech community of Bronx (a section of New York City) have slightly different phonological knowledge from those who grew up in the speech community of New York City). As one can imagine, the list of different speech communities that one can identify in terms of phonological knowledge is very long—and here we restricted ourselves just to American English. The same point applies to any natural language.

After we restrict our attention to the members of a particular speech community, we can then turn to another question: How many members of a given speech community manage to acquire the phonological knowledge that is common in that community? Of course, here the answer is deceptively simple: All of them do.⁷ This answer is *deceptively* simple because it presents a rather difficult problem for the scientist to understand: Because every member of a speech community comes to possess the phonological knowledge of that speech community, and because one's

⁶ Where "part" is defined not just along geographic lines, but also, potentially, along socio-economic lines.

⁷ We should include a small caveat here. All of those who have physically normal speech organs and physically normal brains and who have been exposed to the sounds of a given speech community also acquire the knowledge of that sound system, that is, its phonology.

knowledge of phonology turns out to be very, very complex stuff, the scientist studying the phenomenon has to explain not only what phonological knowledge consists of (as we've started to do in this chapter), but also how it is possible for every child to master this knowledge without fail. Many linguists have concluded that the only way to explain this perfect rate of successful learning in the face of extremely difficult and abstract material is to assume that children are born with a set of phonological constraints already in place, that is, that these phonological constraints are innately given as part of the genetic endowment. Does this conclusion seem surprising?

Exercises

Exercise 1: Vowels in American English

a. Consider the American English vowels [ow] vs. [o'w] and [iy] vs. [i'y] (recall that the diacritic

[:] indicates vowel length) and determine whether they are allophones of the same phoneme, or represent two different phonemes. If the sounds are allophones of the same phoneme, determine whether they are in free variation or complementary distribution. If they are in complementary distribution, state the rule(s). In any case, state the evidence that supports your analysis.

1. [roːwd]	road	6. [liːyg]	league
2. [rowt]	rote	7. [liyk]	leak
3. [toːwb]	Tob (nickname for Toby)	8. [fiːyd]	feed
4. [towp]	tope (a kind of shark)	9. [fiyt]	feet
5. [owgreydiy]	O'Grady (name)	10.[riygard]	regard

b. Determine for yourself whether the other vowels in American English display the same longshort alternation (e.g., *pot* vs. *pod*). If they do, alter the rules you wrote above to cover these cases.

2. Exercise 2: Vowels in American English. Consider the tense-lax alternations in the vowels [iy] vs. [I] and [ey] vs. [ϵ] in American English and determine whether they are allophones of the same phoneme, or represent two different phonemes. If the sounds are allophones of the same phoneme, determine whether they are in free variation or complementary distribution. If they are in complementary distribution, state the rule(s). In any case, state the evidence that supports your analysis.

1. [biyt]	beat	8. [bɪt]	bit
2. [hiyt]	heat	9. [hɪt]	hit
3. [miyt]	meet	10. [mɪt]	mitt
4. [siyt]	seat	11. [sɪt]	sit
5. [beyt]	bait	12. [ba	et] bet
6. [leyt]	late	13. [lɛt]	let

7. [feyd] fade

14. [fɛd] fed

Exercise 3: Vowels in German. Consider the vowels [a] vs. [a:] (recall that the diacritic [:] indicates length) in the following data from German and determine whether they are allophones of the same phoneme, or represent two different phonemes. If the sounds are allophones of the same phoneme, determine whether they are in free variation or complementary distribution. If in complementary distribution, state the rule(s). In any case, state the evidence that supports your analysis.

1. [anə] 'Anne'	2. [aːnə] 'ancestor'
3. [baːlə] Bahle (family name)	4. [balə] '(of the) ball'
5. [haːrə] 'hairs'	6. [harə] (I) 'wait patiently'
7. [maːtə] 'mates' (naval)	8. [matə] 'mats'
9.[aːlə] 'leather-working tool'	10. [alə] 'all'
11. [fɑːnə] 'flag'	12. [fanə] 'frying pan'

Exercise 4: Vowels in German.

a. Consider the tense-lax alternations in the vowels [i] vs. [1] in the following data from German and determine whether they are allophones of the same phoneme, or represent two different phonemes. If the sounds are allophones of the same phoneme, determine whether they are in free variation or complementary distribution. If in complementary distribution, state the rule(s). In any case, state the evidence that supports your analysis.

1. [miːtə] 'rent'	2. [mɪtə] 'middle'
3. [vi:Dr] 'again'	4. [vIDr] 'ram' (male sheep)
5. [li:ft] (y'all) 'ran'	6. [lɪft] 'elevator'
7. [be:t] (plant) 'bed'	8. [bɛt](sleeping) 'bed'
9. [fe:tə] 'celebrations'	10. [fɛtə] 'fats'
11. [keːlə] 'throat'	12. [kɛlə] 'ladel'

b. Now consider [e] vs. [ε] in the data above. Does the same system appear to apply to this pair of sounds as well?

Exercise 5: English-German Interlanguage

Review your findings from exercises 1-4 to locate where the German and English vowel systems differ significantly. On the basis of this difference, predict which of the following *mis*pronunciations might be produced by the English-speaking learner of German.

- 1. [fɛlr] instead of [feylr] 'mistake'
- 2. [viygə] instead of [vegə] 'paths'
- 3. [feyl] instead of [fɛl] 'fur'
- 4. [lɛbm] instead of [liybm] 'to love'
- 5. [lagn] instead of [la:gn] 'lay'
- 6. [hak] instead of [ha:k] 'hang up'

Note: The hidden assumption behind this exercise is that the grammar of the native language transfers to form a learner's grammar of the second language. In fact, while *transfer* does play a role, it has become clear that not everything transfers. Among the most difficult research problems to solve is thus what transfers, what doesn't, and, crucially, why.

Exercise 6: Canadian French [t] vs. [c]. Consider the consonants [t] vs. [c] (voiceless alveolar affricate) in the following data from Canadian French and determine whether they are allophones of the same phoneme, or represent two different phonemes. If the sounds are allophones of the same phoneme, determine whether they are in free variation or complementary distribution. If they are in complementary distribution, state rules. State the evidence that supports your analysis. (Note: [ü] is the rounded high front tense vowel and [ö] is the rounded high front lax vowel.)

1. [tu]	all	2. [abuci]	ended
3. [telegram]	telegram	4. [trɛ]	very
5. [tɛl]	such	6. [tab]	stamp
7. [külcür]	culture	8. [minüt]	minute
9. [cimɪd]	timid	10. [cü]	you
11. [cɪt]	title	12. [cüb]	tube

Exercise 7: Vowels in American English (northern varieties)

a. Consider the vowels [ay] vs. [Ay] in the following data from northern varieties of American English (e.g., in the speech of Peter Jennings, who is Canadian) and determine whether they are allophones of the same phoneme, or represent two different phonemes. If the sounds are allophones of the same phoneme, determine whether they are in free variation or complementary distribution. If they are in complementary distribution, state rules. State the evidence that supports your analysis.

1. [bлyt]	bite	2. [fлyt]	fight
3. [taym]	time	4. [tay]	tie
5. [tлур]	type	6. [bay]	buy
7. [hawz]	to house (verb)	8. [hʌws]	house (noun)
9. [rлyt]	write	10. [rayd]	ride
11. [k ^h aw]	cow	12. [skʌwt]	scout

b. Now consider the vowels [aw] and [Aw] in the data above. Do the rules you wrote for [ay] vs.[Ay] cover these sounds as well? If not, how could these rules be reformulated?

Exercise 8: English aspiration

a. Consider the consonants [k^h] vs. [k] in the following data from American English and determine whether they are allophones of the same phoneme, or represent two different phonemes. If the sounds are allophones of the same phoneme, determine whether they are in free variation or complementary distribution. If they are in complementary distribution, state rules. State the evidence that supports your analysis.

kinder	13. [ɪn	nk ^h orpreyt]	incorporate
skewed	14. [rɛ	kņsayl]	reconcile
kosher	15. [sə	ək ^h mestr]	sequester
slicker	16. [sk	kılət]	skillet
cooler	17. [rəkʰa	.l] 1	recall
pickle	18. [sk	kwadrən]	squadron
kudos	19. [de	akət]	docket
include	20. [In	ık ^h yuwrəbl]	incurable
kangaroo	21. [sk	kımd]	skimmed
scope	22. [sk	kænd]]	scandal
wicket	23. [hækr]] ł	hacker
ekt] correct	24. [si	ykrət]	secret
	kinder skewed kosher slicker cooler pickle kudos include kangaroo scope wicket	kinder13. [ITskewed14. [rakosher15. [saslicker16. [slcooler17. [rək ^h apickle18. [slkudos19. [dainclude20. [ITkangaroo21. [slscope22. [slwicket23. [hækrrɛkt] correct24. [si	kinder 13. [Ink ^h orpreyt] skewed 14. [rɛknsayl] kosher 15. [sək ^h ʌkɛstr] slicker 16. [skɪlət] cooler 17. [rək ^h al] 1 pickle 18. [skwadrən] kudos 19. [dakət] include 20. [Ink ^h yuwrəb]] kangaroo 21. [skɪmd] scope 22. [skændl] wicket 23. [hækr] 1

b. Now consider the sounds [p] vs. [p^h] and [t] vs. [t^h] in American English. Does the same type of rule appear to apply in these cases, too? If so, rewrite the rule to cover the more general situation. Use natural classes to write the rule. (Hint: Should the rule cover all of the voiceless stops in American English or only three of the four of them?)

Exercise 9: German "ich" vs. "ach". Consider the consonants [x] (voiceless velar fricative) vs. [ç] (voiceless palatal fricative) in the following data from German and determine whether they are allophones of the same phoneme, or represent two different phonemes. If the sounds are allophones of the same phoneme, determine whether they are in free variation or complementary distribution. If they are in complementary distribution, state rules. State the evidence that supports your analysis. (Note: [ö] is the mid front rounded vowel.)

1. [laxən]	to laugh	2. [bax]	stream
3. [lɔx]	hole	4. [ıç]	Ι
5. [špreçən]	to speak	6. [blɛç]	tin
7. [hoːx]	high	8. [fluxən]	to curse
9. [möçtə]	would like	10. [mɪlç]	milk
11. [çınə]	China	12. [doːlç]	dagger

Exercise 10: English syllables. For each of the following words, draw a complete representation of its syllable structure. (Note: You should transcribe each of these words first.)

1. extradite	2. exhale
3. inside	4. entrail
5. orthodox	6. delight
7. elope	8. boston
9. delete	10. metrical

Exercise 11: English light and dark [l]. Consider the consonants [l] vs. [] in the following data from (some varieties of) American English and determine whether they are allophones of the same phoneme, or represent two different phonemes. If the sounds are allophones of the same phoneme, determine whether they are in free variation or complementary distribution. If they are in complementary distribution, state rules. State the evidence that supports your analysis.

1. [liyf]	leaf	2. [p ^h ɪɫ]	pill
3. [fɛɬ]	fell	4. [lænd]	land
5. [lowd]	load	6. [fɛłt]	felt
7. [lɔn]	lawn	8. [diylıvr]	deliver
9. [bołt]	bolt	10. [slæp]	slap
11. [bʊɫ]	bull	12. [iynla	ytn] enlighten