Chapter 4  Phonology and Morphophonology

By the end of this chapter you should be able to:

- understand the difference between a phoneme and an allophone
- determine the distribution of allophones
- write phonological rules using phonological features
- know and understand the main kinds of phonological processes in the world’s languages
- understand basic syllable structure
- be comfortable with determining morphophonological alternations

4.1  Introduction

The previous chapter dealt with the articulatory features of the world’s sounds and signs. It is clear to anyone who has ever studied a foreign language that different languages make use of different subsets of all the available sounds. Furthermore, how these sounds are arranged differ from one language to the next. Whereas phonetics is the study of the linguistic properties of sounds and signs, phonology is the study of how these sounds and signs are organized within a given language or dialect. Research in phonology has revealed that languages tend to avail themselves to the same kinds of phonological rules. Thus, phonology is also the study of the universal grammar of sounds and signs. At the end of this chapter we bring together concepts of morphology and phonology and discuss how they interact.

4.2  The Phoneme

As we just said above, different languages have different sets of sounds. But how do figure out what the set of sounds is in a given language? To this day, numerous languages around the world are lacking a basic description. And even in better studied languages there are rare dialects that have not been adequately recorded. In the early 20th Century, structural linguists such as Ferdinand de Saussure, Leonard Bloomfield and André Martinet developed a methodology for determining the set of sounds for a given language or dialect. They relied on the notion of contrast to guide their inquiry. They proposed the following definition.

**Phoneme**

the smallest segmental unit of sound employed to form meaningful contrasts between utterances
Leonard Bloomfield was an American linguist in the early 20th century who specialized in Indo-European, Austro-Asian, and Algonquian languages. He was the founder of structuralism, which characterizes the approach to phonology presented in this chapter. He conducted much fieldwork on Algonquian languages in North America.

A “segmental unit of sound” is the smallest isolable bit of sound. Consider the English word “dog”. You can articulate the [d], [a], and [g] separately and still tell that they are the sounds of the word “dog”. Consider just the [d], however. It is a voiced alveolar stop. You can’t articulate the voicing separately from the rest of the sound leaving just a [t] and some vague voiced grunt and still expect people to know that these are the sound components of the word “dog”. The [d] is an atomic package as far as determining the sounds of a word (though we will see below that phonology can manipulate the features of sounds and change them around). Thus, [d] is a segmental unit of sound. Now, what do we mean by ‘meaningful contrasts’? Consider the following pairs of words along with rough phonetic transcriptions. ([k*] indicates a fortis [k]. It is not crucial to the discussion here.)

| (1) | Korean      | [makɾʰa] | ‘clear, clean’ | [nakɾʰa] | ‘old, used’ |
|     | English     | [fi]     | ‘flea’         | [flu]    | ‘flew’      |
|     | Portuguese  | [pɛsa]   | ‘piece’        | [pɛza]   | ‘it weighs’ |

Notice that each pair of words differs by only one segment. Such pairs are called minimal pairs. Looking at the Korean example, the sounds [m] and [n] give rise to a contrast. That is, exchanging one for the other gives rise to a difference in meaning. Thus, we say that [m] and [n] are distinct phonemes in Korean. In English, the vowels [i] and [u] are contrastive because they give rise to the minimal pair shown. Likewise, the sounds [s] and [z] are contrastive in Portuguese.

The phonemic inventory, or set of basic sounds, of a language can be deduced by comparing several minimal pairs of the language. In actual practice, hundreds of minimal pairs should be contrasted to ensure you have an accurate and complete phonemic inventory. Some sounds in a language could be quite rare. For instance, the sound [ʒ] is somewhat rare in English, occurring only in a few words (beige, illusion, vision, etc.). Indeed, it is quite difficult to construct a minimal pair for [ʒ] and [ʒ] in English. There are at least two such pairs, however: Aleutian/allusion and mesher/measure. Sometimes, a set of data may be limited, in which case we can rely on near minimal pairs.
Practice 4.1

Find as many minimal pairs in the following Ainu data as you can. List all the phonemes you can determine.

<table>
<thead>
<tr>
<th>Minimal Pair</th>
<th>Near Minimal Pair</th>
</tr>
</thead>
<tbody>
<tr>
<td>[mɛʃũ]</td>
<td>[pɛlufɔn]</td>
</tr>
<tr>
<td>[mɛʒũ]</td>
<td>[kɛlufɔn]</td>
</tr>
</tbody>
</table>

identical except for [ʃ] and [ʒ]

This difference is far enough away from the segments being tested that we can be fairly certain that [ʃ] and [ʒ] are contrastive.

Practice 4.1

Find as many minimal pairs in the following Ainu data as you can. List all the phonemes you can determine.

- [arʃa] ‘to be in pain’
- [arʃa] ‘to go’
- [ حالة] imperative particle
- [tani] ‘now’
- [kusu] ‘because’
- [esani] ‘peninsula’
- [sapa] ‘head’
- [poru] ‘big’
- [tap] ‘shoulder’
- [mak] ‘mountain side’
- [kuru] ‘person’
- [sapo] ‘older sister’
- [mat] ‘wife’
- [poru] ‘cave’
- [tan] ‘this’ (demonstrative)
- [talan] ‘such’
- [tup] ‘two’
- [rusuy] ‘to want’

4.3 Allophonic Variation

Let’s begin by looking at the sounds [s] and [ʃ] in Korean. Consider the following data.

(2) $[sagwa] \quad \text{‘apple’} \quad [ʃip^{*}a] \quad \text{‘want’}$

$[kasəl] \quad \text{‘temporary installation’} \quad [ʃip] \quad \text{‘ten’}$

$[mɛŋsə] \quad \text{‘oath’} \quad [kəʃi] \quad \text{‘thorn’}$

$[suwən] \quad \text{‘Suwon’ (a city)} \quad [ʃilə] \quad \text{‘Silla’ (a historical period)}$

$[səɾi] \quad \text{‘director’} \quad [maʃiɾa] \quad \text{‘drink’}$

$[soret] \quad \text{‘sound’} \quad [ʃiɾa] \quad \text{‘eat’ (honorific)}$
Looking through these data you will notice that there are no minimal pairs for [s] and [ʃ]. That is, there is no environment where you could find either one of these two sounds. Examining the data further you will notice that the distribution is predictable. To figure out the distribution, it is helpful to build a chart listing the sounds that appear immediately before and after the sound in question. In the left-hand column we write the sound that immediately precedes the sound in question, and in the right-hand column we write the sound that immediately follows the sound in question. If the sound is at the beginning or end of a word, we use the symbol, #, to mark a word boundary.

<table>
<thead>
<tr>
<th></th>
<th>[s]</th>
<th>[ʃ]</th>
</tr>
</thead>
<tbody>
<tr>
<td>#</td>
<td>a</td>
<td>#</td>
</tr>
<tr>
<td>a</td>
<td>ά</td>
<td>a</td>
</tr>
<tr>
<td>i</td>
<td>ε</td>
<td>i</td>
</tr>
<tr>
<td>#</td>
<td>u</td>
<td>i</td>
</tr>
<tr>
<td>i</td>
<td>a</td>
<td></td>
</tr>
<tr>
<td>#</td>
<td>o</td>
<td></td>
</tr>
</tbody>
</table>

The distribution of [s] and [ʃ] is now quite clear. [ʃ] appears before the vowel [i], and [s] appears elsewhere. Note that the preceding sound does not play a role since there are some environments that are the same for the preceding sound. When two or more sounds occur in a predictable distribution we call them *allophones*. Thus, in Korean [s] and [ʃ] are allophones of a single phoneme. By convention, the label of the phoneme is the allophone with the widest distribution. [ʃ] appears before /i/, and [s] appears elsewhere, so we can also call [s] the elsewhere case. The distribution of allophones is typically represented in a tree as follows. The following tree is read as follows: “/s/ becomes [ʃ] when it appears before /i/ and become [s] when it appears elsewhere.

**Ainu** is a language isolate now spoken only the island of Hokkaido in northern Japan. It is extremely endangered with only a small handful of elderly speakers left, although revitalization efforts are underway (DeChicchis, 1995). The grammar of the modern language shares some similarities with Japanese (for instance it is SOV and has postpositions). However, classical Ainu had a number of polysynthetic properties such as noun incorporation (p. 47).

**mukcar-aha**  a-tuye  a-mukcar-tuye
**chest-POSS**  1.SG.SUBJ-cut  1.SG.SUBJ-chest-cut
‘I cut his chest.’  ‘I cut his chest.’  (Shibatani, 1990)
distribution of allophones

This alternation can also be captured by a phonological rule, as shown here. This rule is read as “‘ess’ becomes ‘esh’ when it appears before ‘i’.”

\[ /s/ \rightarrow [ʃ] / \_ i \]

phonological rule

Note carefully that the allophones appear in square brackets and that the phoneme appears between slashes. Please remember this for the discussion below.

<table>
<thead>
<tr>
<th>Phonological Rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>/x/ → [y] / _ a</td>
</tr>
<tr>
<td>“x becomes y when it appears before a”</td>
</tr>
<tr>
<td>/x/ → [y] / a _</td>
</tr>
<tr>
<td>“x becomes y when it appears after a”</td>
</tr>
<tr>
<td>/x/ → [y] / a _ b</td>
</tr>
<tr>
<td>“x becomes y when it appears between a and b”</td>
</tr>
<tr>
<td>/x/ → Ø / _ a</td>
</tr>
<tr>
<td>“delete x before a”</td>
</tr>
<tr>
<td>Ø → [x] / _ a</td>
</tr>
<tr>
<td>“insert x before a”</td>
</tr>
</tbody>
</table>

Common symbols in the conditioning environment:

- C - any consonant
- V - any vowel
- C₁³⁰ - zero to one consonants
- V₁° - at least one vowel
- # - word boundary
- $ - syllable boundary
- + - morpheme boundary
- Ø - empty
Practice 4.2

For each rule below, determine the output for the various inputs given to the right of the rule.

\[
\begin{align*}
/t/ &\rightarrow [s] /C \_\_ i & /pti/ & /pta/ & /kti/ & /ti/ & /tik/ & /pto/ \\
\emptyset &\rightarrow [t] /V \_ V & /ia/ & /tat/ & /foa/ & /ona/ & /beana/ & /fiat/ \\
\end{align*}
\]

Let us continue by looking at the sounds [t], [ʧ], and [ʦ] in the following (slightly simplified) Japanese data. Although vowel length is indicated in these data, assume that it does not play a role here.

(3)

<table>
<thead>
<tr>
<th></th>
<th>‘mat’</th>
<th>‘police’</th>
<th>‘hotel’</th>
</tr>
</thead>
<tbody>
<tr>
<td>[tatami]</td>
<td>[keisatsu]</td>
<td>[hoteru]</td>
<td></td>
</tr>
<tr>
<td>[itsui]</td>
<td>[hito]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[ʧikai]</td>
<td>[takai]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

We see that there are no minimal pairs, so we make a chart to examine the distribution of these phones.

<table>
<thead>
<tr>
<th>[t]</th>
<th>[ʦ]</th>
<th>[ʧ]</th>
</tr>
</thead>
<tbody>
<tr>
<td>#</td>
<td>a</td>
<td>u</td>
</tr>
<tr>
<td>a</td>
<td>a</td>
<td></td>
</tr>
<tr>
<td>i</td>
<td>o</td>
<td></td>
</tr>
<tr>
<td>o</td>
<td>e</td>
<td></td>
</tr>
<tr>
<td>#</td>
<td>oː</td>
<td></td>
</tr>
</tbody>
</table>

Again, the pattern is clear. The distribution of these sounds is triggered by the following vowel. Thus, /t/ has three allophones, which can be captured by the following chart on the left or by the rules on the right.
Practice 4.3

Determine whether [i] and [ɪ] are two distinct phonemes or allophones of the same phoneme in Cantonese (tones omitted). If they are distinct phonemes state your evidence. If they are allophones of the same phoneme, state their distribution and write a rule to account for the distribution.

| [si] | ‘poetry’ | [ʦɪŋ] | ‘clear’ |
| [tim] | ‘sweet’ | [bɪŋ] | ‘ice’ |
| [wudip] | ‘butterfly’ | [ni] | ‘this’ |
| [sɪk] | ‘eat’ | [bin] | ‘flat’ |
| [lɪŋ] | a surname | [jik] | ‘one hundred million’ |

Finally, segments may exist in free variation. A minimal pair may be found; however, there is no difference in meaning. In English plain t, [t], and unreleased t, [t̚], are in free variation in word-final position. Thus, the word hat can be pronounced [hæt] or [hæt̚]. Although segments in free variation do not give rise to differences in lexical meaning, they may give rise to sociolinguistic distinctions such as speech style (casual, monitored, or formal) or speaker relations (honorific or intimate).

4.4 Phonological Features and Rules

We will start this section with a brief look at some (slightly simplified) Korean data. Pay particular attention to the oral stop consonants (aside from [t*]). The distribution charts have been made below the data for your convenience.

| [ياة] | ‘monthly’ | [طا] | ‘tea room’ |
| [جساووا] | ‘embassy’ | [پنو] | ‘grape’ |
| [پاکٰنی] | ‘to drive in / hammer’ | [پاگٰنی] | ‘peninsula’ |
| [کاچا] | ‘to go’ | [پاپ] | ‘cooked rice’ |
| [کابا] | ‘wig’ | [پاگٰنی] | ‘to carry on one’s back’ |
| [کانگا] | ‘riverside’ | [جا] | ‘to be sweet’ |
Observe that a pattern emerges only once we consider what appears on both sides of the segment in question. Consider the following allophone distribution charts and their associated phonological rules. The rules seem somewhat complex until we consider what the triggering segments all have in common.

(5) /t̪/ → [d̪] / {l̪, n̪, V} __ V  
/k/ → [ɡ] / {ŋ, V} __ {V, w}

Notice that both sides of the triggering environment always have a voiced sound. Rather than list an assortment of sounds as the triggers of voicing, let’s assume that there is a phonological feature [+voice] that triggers voicing. We can re-write the rules in a much simpler way.

(7) /t̪/ → [d̪] / [+voice] __ [+voice]  
/k/ → [ɡ] / [+voice] __ [+voice]

Now, if we consider these rules more closely we see that they describe the same general process for /t/, /p/ and /k/. Is there a general statement we can make about these three rules? It seems as though voiceless consonants become voiced between two voiced segments. We can write a single rule as follows to account for the distribution of all six sounds. Such rules, where segment becomes voiced between two voiced segments is extremely common in the world’s languages and is referred to as **intervocalic voicing**.

(8) {t̪, p, k} → [+voice] / [+voice] __ [+voice]

We may ask if the sounds in the input all have something in common. We could come up the following rule to simplify the rule in (8).

(9) [-voice] → [+voice] / [+voice] __ [+voice]
We can test the validity of this rule by looking at the behaviour of other voiceless sounds in Korean. Consider the following additional data (note also the word for ‘embassy’ in the set of data in (4) above).

(10) $\text{[saɡwa]}$ ‘apple’ $\text{[isam]}$ ‘a few’
$\text{[il ̪ sɛŋ]}$ ‘lifetime’ $\text{[musɨn ̪ ]}$ ‘what kind’

Here, /s/ does not become voiced to become [z]. Thus the rule in (9) must be revised. What do /t̪/, /p/, and /k/ have in common in contrast to /s/? /s/ is a fricative in contrast to the other sounds, which are stops or plosives. Phonologists use the feature [+continuant] to describe any sound with a constant flow of air through the oral tract. The rule that captures all these facts is shown below. (We will talk more about phonological features below.) /s/ has a constant flow of air through the oral tract, so it is [+continuant]. /t̪/, /p/, and /k/ do not have a constant flow of air through the oral tract, so they are [-continuant].


Let’s consider for a moment why we might want to state the rule for intervocalic voicing in Korean as in (11) as opposed to as in (6). There are two important reasons for this. First, we want to capture a generalization about the phonology of Korean. Specifically, we want to say that intervocalic voicing is a property of oral stop consonants in general. The rule in (11) captures this generalization. Second, we want to be able to write only those rules that are likely to be found in natural language. Consider the following two hypothetical rules.

(12) a. \( /s/ \rightarrow [z] / \{i, a, u\} \)
    b. \( /s/ \rightarrow [q'] / \{r, w, o\} \)

The first rule is one which is quite plausible, while the second is extremely unnatural, and unlikely to be found in any language. Both of these rules are very easy to write in their current forms. However, if we refer only to phonological features, then only the first rule is easy to write. We will come back to this point below.

Let us now examine the various phonological features that are found in natural language.

4.4.1 Phonological Features

In this section we cover each phonological feature in detail. Recall from the previous chapter that phonetic features refer to how sounds are articulated. They are constant across languages. Phonological features, on the other hand, capture the behaviour of sounds in a particular language, and thus are subject to cross-linguistic variation. The descriptions below indicate the expected phonological features found on the segments discussed. Furthermore, not all features are active in every language. If a language has no lateral sounds, for example, it would be redundant to label every phoneme in the language [-lateral]. Since these are the expected properties of the sounds listed below evidence to the contrary is needed to propose a feature specification that departs from these expectations. For example, if a given language has the phoneme /l/, we assume that it is [+continuant] unless there is evidence to the contrary. Most of the important features are given below, along with their standard abbreviations. This list of fea-
Consonant Features - Manner

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>[+voice]</td>
<td>refers to the activity of the vocal folds</td>
</tr>
<tr>
<td>[+voi]</td>
<td>vocal folds are vibrating</td>
</tr>
<tr>
<td>[-voi]</td>
<td>vocal folds are open</td>
</tr>
<tr>
<td>[-cont]</td>
<td>airflow is stopped along the oral tract, includes plosives, nasals, and affricates on the IPA chart</td>
</tr>
<tr>
<td>[+cont]</td>
<td>constant airflow in the oral tract</td>
</tr>
<tr>
<td>[+son]</td>
<td>non-turbulent airflow, includes nasals, trills, flaps, approximants, and vowels on the IPA chart</td>
</tr>
<tr>
<td>[-son]</td>
<td>strongly turbulent or blocked airflow</td>
</tr>
<tr>
<td>[+nas]</td>
<td>lowered velum allowing airflow through the nasal cavity</td>
</tr>
<tr>
<td>[-nas]</td>
<td>raised velum allowing airflow only through the oral cavity</td>
</tr>
<tr>
<td>[+sib]</td>
<td>airflow is directed towards the tip of the teeth: s, z, j, ʒ, ʂ, r, l, l, dz, l, dz, l, dz</td>
</tr>
<tr>
<td>[-sib]</td>
<td>all other sounds</td>
</tr>
</tbody>
</table>

Consider the following carefully transcribed English data. Note that . indicates a syllable boundary. Observe that vowels in English become nasal if they precede a nasal consonant in the same syllable. The rule below the data captures this fact. Note that we can informally use the symbol V to indicate the feature set [+voi, -cons]. We can also use the symbol C to indicate [+cons]. Recall that glottal sounds such as /h/ are actually [-cons]. Authors vary as to whether C is meant to include /h/ or not. In practice, you should indicate whether /h/ is included in C or not, if this matters for
your discussion. Note that an additional consonant may appear between the nasal consonant and the syllable boundary. We indicate that this consonant is optional by placing it in brackets.

\[(13)\] 

- [θɪ̃ŋk] 'think'
- [θɪk] 'thick'
- [sæ̃ŋk] 'sank'
- [sæk] 'sack'
- [lɪ̃mp] 'limp'
- [lɪp] 'lip'
- [fẽm] 'fame'
- [fe.mǝs] 'famous'
- [dɒm] 'dome'
- [hæ.mɹ] 'hammer'
- [sʌ̃m] 'some'
- [sʌ.mɹ] 'summer'
- [dɛ̃nt] 'dent'
- [dɛt] 'debt'

\[V \rightarrow [+nasal] / \_ [+nasal](C)\]

Here is a final illustration. Consider the following Canadian French data, paying close attention to the alveolar consonants.

\[(14)\] 

- [tu] 'all'
- [ʦy] 'you'
- [lyte] 'to fight'
- [ʣy] 'of the' (MASC.SING)
- [du] 'sweet'
- [ʦiʁe] 'to pull'
- [dwen] 'customs'
- [ɔʤɪnətɛʁ] 'computer'
- [dɔ̃e] 'to give'
- [aktsɪf] 'active'
- [itali] 'Italy'
- [ʦɪp] 'type'
- [asasine] 'to assassinate'
- [ziti] 'ziti' (a type of pasta)
- [ɔkype] 'to occupy'
- [piknɪk] 'picnic'

From these data, we can determine the following phonological rules. (If you don’t see the pattern right away, construct charts as we did for example (4) above.)

\[(15)\] 

\[/t/ \rightarrow [ʦ] / \{i, y\}\]

\[/d/ \rightarrow [ʣ] / \{i, y\}\]

Again, we see that this is the same basic rule, so we restate it as follows. (See below for the feature \([+coronal]\), which restricts the rule to applying only to alveolar consonants.)

\[(16)\] 

\[\begin{array}{c}
  \text{[+coronal]} \\
  \text{[−continuant]} \\
  \text{[−sonorant]} \\
\end{array} \rightarrow \text{[−del rel]/} \_ \begin{array}{c}
  \text{[+hi]} \\
  \text{[+front]} \\
\end{array}\]

Next we turn to place features of consonants.
Consonant Features - Place

- **[±labial]** – refers to the participation of one or both lips in the articulation of a sound
  - **[+labial]** – one or both lips are involved in sound production
  - **[-labial]** – lips are not involved in sound production
  
  The bilabial, labiodental, and all other sounds with a labial designation (such as [w]) are **[+labial]**

- **[±coronal]** – refers to the use of the tip or blade of the tongue
  - **[+coronal]** – the tip/blade of the tongue is raised, this includes all dental, alveolar, postalveolar and retroflex consonants
  - **[-coronal]** – the tip/blade of the tongue is in neutral position

- **[±anterior]** – refers to the place of sounds, using the alveolar ridge as a dividing line
  - **[+ant]** – all sounds articulated in front of and including the alveolar ridge
  - **[-ant]** – all sounds articulated behind the alveolar ridge

- **[±lateral]** – refers to the activity of the sides of the tongue
  - **[+lateral]** – one or both sides of the tongue is lowered, includes all the laterals on the IPA chart
  - **[-lateral]** – the sides of the tongue are not lowered

- **[±dorsal]** – refers to the activity of the back of the tongue
  - **[+dorsal]** – the back of the tongue is raised, includes palatals, velars and uvulars on the IPA chart
  - **[-dorsal]** – the back of the tongue is not raised

- **[±palatal]** – refers to the position of the back of the tongue
  - **[+palatal]** – the back of the tongue is raised and moved forward, includes palatals
  - **[-palatal]** – the back of the tongue is not raised and moved forward

Consider the following Turkish data, paying attention to the dorsal consonants. Again, the sign . indicates a syllable boundary.

(17)  
<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>bak.la</td>
<td>‘broad beans’</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ok.ʃa</td>
<td>‘caress’</td>
<td></td>
<td></td>
</tr>
<tr>
<td>kʰa.fa</td>
<td>‘head’</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ic.na</td>
<td>‘convince’</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ec.si</td>
<td>‘minus’</td>
<td></td>
<td></td>
</tr>
<tr>
<td>çʰo.myr</td>
<td>‘coal’</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>[stu.ku]</td>
<td>‘squeezed’</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[park.ta]</td>
<td>‘in the park’</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[stu.ka.ul]</td>
<td>‘tight’</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[ek.łe]</td>
<td>‘add’</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[eʰe.çi]</td>
<td>‘goat’</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[i.eʰi]</td>
<td>‘two’</td>
</tr>
</tbody>
</table>

From these data we can determine that [k], [kʰ], [c], and [çʰ] are all in complementary distribution and thus are allophones of the same phoneme. The following chart gives the distribution of these four allophones. Note that any one of the four consonants could have been chosen as the elsewhere case; however, /k/ is the *least marked* (the most common cross-linguistically, roughly speaking), so it is chosen as the basic phoneme.
The two palatal stops appear only in the context of front vowels, and the two velar stops appear only in the context of back vowels. In both cases, aspirated versions appear when the consonant is to the left of the vowel in the syllable. These two facts are captured by the following rules. Note that although we have no evidence to the contrary, let’s assume that this process is restricted to oral stops. Front vowels (see below) trigger the dorsal consonant to become palatal. Appearing before the vowel of the syllable triggers the consonant to become aspirated, which we capture with the feature [+spread glottis] or [+SG] for short.

\[
\begin{align*}
\text{[+dorsal]} & \rightarrow [+\text{palatal}] /[(+\text{front})] \quad \rightarrow / (\text{[+front]}) \quad $ \\
\text{[−continuant]} & \rightarrow / (\text{[+dorsal])} \quad $ \\
\text{[−nasal]} & \rightarrow / (\text{[+front]}) \quad $ \\
\text{[+dorsal]} & \rightarrow / [SG] / $ \quad _{V} \\
\end{align*}
\]

As a final illustration, consider the following Cantonese data (tones omitted), paying attention to the high vowels.

\[
\begin{align*}
\text{[sɪ]} & \quad \text{‘poetry’} \\
\text{[lɪp]} & \quad \text{‘elevator’} \\
\text{[hɪŋty oy]} & \quad \text{‘interest’} \\
\text{[bɪn]} & \quad \text{‘nose’} \\
\text{[bʊn]} & \quad \text{‘half’} \\
\text{[guwak]} & \quad \text{‘sneaky’} \\
\text{[nam]} & \quad \text{‘male’} \\
\text{[tʰɪm]} & \quad \text{‘sweet’} \\
\text{[sɪk]} & \quad \text{‘to eat’} \\
\text{[tʰit]} & \quad \text{‘iron’} \\
\text{[dɪksi]} & \quad \text{‘taxi’} \\
\text{[jʊk]} & \quad \text{‘meat’} \\
\text{[sʰon]} & \quad \text{‘heavy’} \\
\text{[bək]} & \quad \text{‘white’} \\
\end{align*}
\]

From the data presented above we can determine the following rules for [i] and [u].

\[
\begin{align*}
/i/ & \rightarrow /i/ \quad _{(\{\eta, k\})} \\
/u/ & \rightarrow /u/ \quad _{(\{\eta, k\})}
\end{align*}
\]

These two rules can be conflated into the following single rule. Note that the vowel features are introduced below, and that /g/ is absent in the conditioning environment because it is never found at the end of the word in Cantonese.

\[
[+\text{hi}] \rightarrow [-\text{tns}] \quad _{(\{+\text{dorsal}\})}
\]
### Vowel Features

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>±high</td>
<td>refers to the vowel height</td>
<td>ei, ey, i, u, ʉ, u, ʊ</td>
</tr>
<tr>
<td>+hi</td>
<td>phonetically high (close) vowels</td>
<td>i, y, y, i, u, ʉ, u, ʊ</td>
</tr>
<tr>
<td>-hi</td>
<td>all other vowels</td>
<td></td>
</tr>
<tr>
<td>±low</td>
<td>refers to the vowel height</td>
<td>æ, a, ɶ, ɐ, ɑ, ɒ</td>
</tr>
<tr>
<td>+low</td>
<td>phonetically low (open) vowels</td>
<td>æ, a, ɶ, ɐ, ɑ, ɒ</td>
</tr>
<tr>
<td>-low</td>
<td>all other vowels</td>
<td></td>
</tr>
<tr>
<td>±back</td>
<td>refers to vowel placement</td>
<td>a, nd, [a]</td>
</tr>
<tr>
<td>+back</td>
<td>phonetically back and central vowels, and [a]</td>
<td>a, nd</td>
</tr>
<tr>
<td>-back</td>
<td>phonetically front vowels, except [a]</td>
<td></td>
</tr>
<tr>
<td>±round</td>
<td>refers to lip rounding on vowels</td>
<td>y, ɨ, ʉ, u, ʊ, ø, ɵ, o, œ, ɞ, ɔ, ɶ, ɒ</td>
</tr>
<tr>
<td>+rnd</td>
<td>phonetically round vowels</td>
<td>y, ɨ, ʉ, u, ʊ, ø, ɵ, o, œ, ɞ, ɔ, ɶ, ɒ</td>
</tr>
<tr>
<td>-rnd</td>
<td>all other vowels</td>
<td>i, e, æ, a, i, ɨ, ɘ, ə, ɜ, ɐ, ɯ, ɤ, ʌ, ɑ</td>
</tr>
<tr>
<td>±tense</td>
<td>refers to vowel tenseness/tongue root position (also called [±ATR])</td>
<td>a, nd</td>
</tr>
<tr>
<td>+tns</td>
<td>advanced tongue root position</td>
<td></td>
</tr>
<tr>
<td>-tns</td>
<td>retracted tongue root position</td>
<td></td>
</tr>
</tbody>
</table>

Any vowel can be specified as [+tns] if the feature is phonologically active in the language. In English, the following vowels are [+tns]: i, e, o, a

We use these features to determine natural classes for our phonological rules. Let's look at some examples to illustrate how these features are used. Consider the following Canadian English data. These data represent a phenomenon known as the Canadian Raising.

(22)  
<table>
<thead>
<tr>
<th>Word</th>
<th>Pronunciation</th>
</tr>
</thead>
<tbody>
<tr>
<td>ice</td>
<td>[ʌɪs]</td>
</tr>
<tr>
<td>height</td>
<td>[haɪt]</td>
</tr>
<tr>
<td>life</td>
<td>[laɪf]</td>
</tr>
<tr>
<td>clout</td>
<td>[klʌʊt]</td>
</tr>
<tr>
<td>house</td>
<td>[hɑʊs]</td>
</tr>
<tr>
<td>pout</td>
<td>[pʌʊt]</td>
</tr>
<tr>
<td>eyes</td>
<td>[ajz]</td>
</tr>
<tr>
<td>hide</td>
<td>[haɪd]</td>
</tr>
<tr>
<td>lie</td>
<td>[lai]</td>
</tr>
<tr>
<td>cloud</td>
<td>[ klaʊd]</td>
</tr>
<tr>
<td>houses</td>
<td>[hɑʊzəz]</td>
</tr>
<tr>
<td>pow</td>
<td>[paʊ]</td>
</tr>
</tbody>
</table>

Examining these data closely we see that the diphthongs /aɪ/ and /aʊ/ become [ʌɪ] and [ʌʊ], respectively, before voiceless consonants. The head of the diphthong, /a/, has the feature [+low] and the head of the raised diphthong, /ʌ/, has the feature [-low], so we can formulate the following rule to account for the Canadian Raising.

(23)  
V → [-low] / __ V [-voice]
Note that the conditioning environment is slightly more complicated in this rule. This rule states that a vowel (V) becomes [-low] when it appears before an off-glide (V̯) followed by a [-voice] segment. Let’s consider the derivation of the word *ice*, which has the following phonological form: /aɪ̯s/.

\[
\begin{array}{c}
\text{/aɪ̯s/} \\
V \rightarrow [-\text{low}] / __ V [\text{-voice}] \\
[Λɪs]
\end{array}
\]

The /a/ in the initial form (called the **phonological form** below) appears in the environment indicated by the rule, so it becomes [-low].

We have seen a few examples of **palatalization**, in which certain [+coronal] consonants becomes [-anterior] when they appear before [j] or before certain [-back] vowels, usually only [+high, + back] vowels. For instance, we saw above that /s/ palatalizes in Korean before [i].

As a final illustration of vowel features, consider the following Japanese data. The diacritic [˳] refers to devoicing. Thus [i̥] is a voiceless [i]. The following data are typical of Tokyo Japanese; however, vowel devoicing is quite variable throughout Japan. There are additional factors affecting vowel devoicing in Japanese, which are not addressed here.

\[
\begin{align*}
\text{[ki̥keŋ]} & \quad \text{‘danger’} \\
\text{[kijkai]} & \quad \text{‘machine’} \\
\text{[uikatsu]} & \quad \text{‘careless’} \\
\text{[çiʃiʃka]} & \quad \text{‘paternal side’} \\
\text{[kəʃʊtwór]} & \quad \text{‘medicine’} \\
\text{[ʧiʃka]} & \quad \text{‘underground’} \\
\text{[keʃatsu]} & \quad \text{‘police’} \\
\text{[oʃiʃxaŋ]} & \quad \text{‘Okiku’ (a name)}
\end{align*}
\]

The triggering environment for devoicing is [-voice] __. The vowels that undergo devoicing are /i/ and /ɯ/, which share the feature [+hi]. Thus, the rule for devoicing in Japanese is as follows.

\[
\begin{array}{c}
[+\text{hi}] \rightarrow [-\text{voice}] / [-\text{voice}] __
\end{array}
\]

Based on this discussion, which vowels in (3) above do you think are devoiced?
4.4.2 Phonological Representations

Let’s think a moment about what our phonological rules are doing. They account for generalizations about the behaviour of sounds in a simple and elegant way. Recall again the distribution of [s] and [ʃ] in Korean from above. We can re-write the phonological rule as follows.

(26) /s/ → [-anterior] / __ [+hi, -back]

Since we have a rule to account for this sound change, there is no need to record this information in the mental lexicon of a Korean speaker. The lexical entry consists just of that information that is unpredictable. Since the distribution of [s] and [ʃ] is entirely predictable in Korean, there is no need to encode it in the lexical entry. We can demonstrate these sound changes in a chart as follows. At the top of the chart are listed the underlying forms (the pronunciation in the lexical entry) of the words we’re interested in. Down the left side of the chart we list the phonological rules under examination. At the bottom of the chart we put the surface forms—the output of the phonological rules. If a given phonological rule doesn’t apply to a given form we can indicate this by placing ‘--’ in the appropriate cell of the chart. Note that once a rule has been stated in full as in (26), the rule can simply be referred to by a perspicuous name (/s/-palatalization) or by a simplified form (/s/ → [ʃ] / __ i).

<table>
<thead>
<tr>
<th>Phonological Form</th>
<th>/sakwa/</th>
<th>/sip/</th>
</tr>
</thead>
<tbody>
<tr>
<td>/s/-palatalization</td>
<td>--</td>
<td>ʃip</td>
</tr>
<tr>
<td>Intervocalic voicing</td>
<td>sagwa</td>
<td>--</td>
</tr>
</tbody>
</table>

| Phonetic Form | [sagwa] | [ʃip] |

**Phonological Form:** contains the *unpredictable* information only…just the phonemes

**Phonetic Form:** contains both the *predictable* and the *unpredictable* information…the allophones
Practice 4.4

Consider the following Swampy Cree data. What phonological rule do you think is necessary to account for these data? Give the derivations for the Swampy Cree words for ‘work’ and ‘there’. Hint: assume that a long vowel, Vː, is a sequence of two vowels, VV.

<table>
<thead>
<tr>
<th>Swampy Cree</th>
<th>Romanization</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>[oʦiːmaːn]</td>
<td>‘his canoe’</td>
<td>[peːdaːw] ‘He brings it.’</td>
</tr>
<tr>
<td>[peːhtaːw]</td>
<td>‘He waits for it.’</td>
<td>[naːbeːw] ‘man’</td>
</tr>
<tr>
<td>[aːbatisiːwin]</td>
<td>‘work’</td>
<td>[kiːbeːʣiniːmiʊ] ‘He came to dance.’</td>
</tr>
<tr>
<td>[maːga]</td>
<td>‘now’</td>
<td>[otakikomio] ‘He has a cold.’</td>
</tr>
<tr>
<td>[anda]</td>
<td>‘there’</td>
<td>[otaːɡoʃin] ‘It is evening.’</td>
</tr>
<tr>
<td>[eːkwani]</td>
<td>‘that!’</td>
<td>[moːla nitoːsitaːn] ‘I’m hard of hearing.’</td>
</tr>
</tbody>
</table>

We’ve seen a number of phonological rules in a wide variety of languages. Let’s consider now, how these rules interact. First, look at the phenomenon of flapping in North American and Australian English. Consider the following data. Note that stress is marked with the diacritic [ˈ].

(27)  
[ˈæd] red  [ˈæ.ɾən] redder  
[ˈwe.ɾɪn] wedding  [ˈæ.ɾəs] address  
[ˈnit] neat  [ˈni.ɾəst] neatest  
[ˈnid] need  [ˈni.ɾi] needy  
[ˈæ.ɾəkt] addict (noun)  [ə.ˈdɪk.ʃə̃n] addiction

The phonemes /t/ and /d/ both share a common allophone, [ɾ], whose distribution is captured by the following rule. For now, we will use the feature [-stress] to refer to a syllable that lacks stress.

Cree is an Algonquian language spoken in central North America. It comprises a dialect continuum that spans several hundred kilometers. Representative members include Plains Cree, Swampy Cree, Woods Cree and Moose Cree.

Cree is written with syllabics or with the Roman alphabet as shown in the two images here. Here are some websites with additional information:
http://www.creedictionary.com/  
http://www.eastcree.org/  
http://www.atlas-ling.ca/
(28) $\{/t/,/d/\} \rightarrow [r] / V - [\text{stres}]$

We simplify this rule using features as follows. We won’t worry about the features for flaps here.

(29) $\left[\begin{array}{c}
-\text{son} \\
-\text{cont} \\
+\text{cor}
\end{array}\right] \rightarrow [r] / V - [\text{stres}]$

Now recall the rule for the Canadian Raising from above.

(30) $V \rightarrow [-\text{low}] / \_ \_ V [-\text{voice}]$

Let’s see how these rules interact. Consider the following data from Canadian English. Note that both the rules for flapping and for Canadian Raising must operate on some of these forms to produce the phonetic forms given.

(31) [ɹʌɪ̯ tɪŋ] ‘writing’       [ɹaɪ̯ ɾɪŋ] ‘riding’
    [pʰʌʊ̯ ɾəd] ‘pouted’       [lɑ̃ɐɾəst] ‘loudest’
    [lʌɪ̯ ɾɪŋ] ‘lighting’       [slaɪ̯ ɾɪŋ] ‘sliding’

The question we ask ourselves, now, is what order these rules apply in. Let’s see what happens if we do the flapping rule first, then the Canadian Raising. To test this, let’s restrict ourselves to the first pair of words. First, the flapping rule applies to both words resulting in the neutralization between the /t/ and the /d/. Both of these sounds become a flap. Now, the triggering environment for the Canadian Raising rule no longer exists. We say that it has been bled. The flapping rule bleeds the Canadian Raising rule by removing a situation in which it can apply. In this case, bleeding gives rise to the wrong result (although in some situations it gives rise to the right result). Here is the chart showing the incorrect derivation for ‘writing’ and ‘riding’, respectively.

<table>
<thead>
<tr>
<th>Phonological Form</th>
<th>/ɪəɾɪŋ/</th>
<th>/ɹaɪ̯ ɾɪŋ/</th>
</tr>
</thead>
<tbody>
<tr>
<td>flapping</td>
<td>ɪəɾɪŋ</td>
<td>ɪəɾɪŋ</td>
</tr>
<tr>
<td>Canadian Raising</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Phonetic Form</td>
<td>[ɪəɾɪŋ]</td>
<td>[ɹaɪ̯ ɾɪŋ]</td>
</tr>
</tbody>
</table>
Let’s see what happens if we reverse the order of these rules. In this case, the rule for the Canadian Raising correctly applies to ‘writing’ but does not apply to ‘riding’. The flapping rule then applies to both forms giving rise to the correct phonetic forms. Here is the chart that shows the opposite ordering of these two rules.

<table>
<thead>
<tr>
<th>Phonological Form</th>
<th>/ɹʌɪ̯ tɪŋ/</th>
<th>/ɹʌɪ̯ ɾɪŋ/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canadian Raising</td>
<td>ɹʌɪ̯ tɪŋ</td>
<td>--</td>
</tr>
<tr>
<td>flapping</td>
<td>ɹʌɪ̯ ɾɪŋ</td>
<td>ɹʌɪ̯ tɪŋ</td>
</tr>
</tbody>
</table>

| Phonetic Form     | [ɹʌɪ̯ tɪŋ] | [ɹʌɪ̯ ɾɪŋ] |

**Practice 4.5**

Consider the following Swahili data and accompanying phonological rules. How do these rules need to be ordered to account for the data?

/npaŋɡɛ/  [pʰaŋɡɛ]  ‘gadfly’
/ntaa/    [tʰaa]   ‘lamp’  [+nasal] → [+labial] / __ [+labial]
/nbu/     [mbu]    ‘mosquito’
/nbɔɡa/   [mbɔɡa]  ‘vegetable’  [+nasal] → Ø / __ [+SG]
/ndizi/   [ndizi]  ‘banana’
/ŋɡɔma/   [ŋɡɔma]  ‘drum’  [−cont] → [+SG]/ [+nasal] __
/panja/   [panja]  ‘rat’

**4.5 Syllable Structure**

You are probably already aware that a stream of speech can be divided into units called syllables. Most of us have an intuitive sense of what a syllable is, but if you actually try to define a syllable to someone, it can be quite tricky. If we have to explain the concept, we usually resort to giving several examples to get the point across. A syllable is a phonological unit of organization, usually consisting of at least a vowel and possibly one or more consonants. More precisely, a syllable can be defined as a sonority peak, where sonority refers to vocal energy—roughly equivalent to loudness. Here is an illustration of sonority peaks for the English sentence, *the bird flew away*. Observe that there are five sonority peaks corresponding to the five syllables of this sentence.
In many languages a syllable may consist of a sequence of a consonant-vowel-consonant, CVC. Consider the English word *beet*.

We should ask ourselves whether this structure accurately represent the facts of the organization of the syllable. We will review several lines of evidence that bear on the matter. First, try saying the sequence [ba] quickly several times in succession: ba ba ba ba ba… How about [ab]?  ab  ab  ab  ab  ab… Which is easier? You will likely notice that the sequence [ba] is much easier to pronounce several times in succession than [ab].

Language games often provide interesting evidence for the underlying structure of language. Specifically, they often illucidate the structure of the syllable. Consider Pig Latin, an English based language game. This game operates on the initial consonant or consonant cluster of the first syllable of each word, although there are different “dialects” of Pig Latin. The initial consonant (or consonant cluster) is placed at the end of the word and “ay” [e] is added. Consider the following examples.

(33)  
dog → og-day  
butter → utter-bay  
snow → ow-snay  
banana → anana-bay
Language games around the world tend treat the initial segment of the syllable as one unit and the vowel plus final consonant as another unit.

Another property distinguishing the initial segments of a syllable from the final segments concerns sound neutralizations, which tend to happen in the final consonant much more commonly than in the initial consonant in a syllable. For example, recall that Korean distinguishes /t/, /tʰ/, /ʰs/, /sʰ/, /ɡ/, /ɡʰ/, and / ɡʰ/. This contrast appears only in the initial portion of the syllable, however. In the final portion of the syllable, these sounds all become neutralized to [tʰ]. Cantonese distinguishes /p/ and /pʰ/, but again only in the initial portion of the syllable. In the final portion, this contrast is neutralized to [pʰ]. Languages typically have a smaller number of consonants available in the final portion of the syllable than in the initial portion. For example, Mandarin allows /s/, /n/, /t/ and /tʰ/ in initial portion of a syllable, but allows only /n/ in the final portion.

Speech errors often involve transposition of the initial consonant in the syllable, but rarely involve transposition of the final consonant. Normally, such errors result in gibberish; however, they can give rise to humorous alternatives.

(34) You missed my history lectures → You hissed my mystery lectures.

The observations above lead to the conclusion that the vowel and final consonant together form a constituent. We say that the syllable is divided into an onset and a rhyme. The rhyme consists of the nucleus – the central sonority peak of the syllable – and the coda.

(35) σ
    \--\n   |  |  |
Onset Rhyme
   |  |  |
 b Nucleus Coda
    |  |  |
i  t

Languages clearly differ in how they structure their syllables. The description of the possible syllable structures for a language is called its phonotactics. A descriptive grammar for a language may give a complete syllabary. This is the case for Japanese, where the writing system is syllabic and the number of possible syllables is small. It is somewhat impractical for English, given the large number of possible syllables. Often, a descriptive grammar will simply describe the possible onsets, nuclei and codas for the language under discussion. Here is a description for the phonotactics of Mong Leng (Mortensen, 2004), a member of the Hmong dialect continuum.

(36) possible syllable types for Hmong: CV(V)C C1C2V(V)C

Onset Nucleus Coda
any single C any V only [ŋ]
C1 = labial or dorsal obstruent diphthong, VV, first V is [a] or [u]
C2 = lateral approximant
The notation C1C2 indicates that a consonant cluster of two consonants is constrained as in the description. The first consonant may be a labial or doral obstruent, and the second consonant must be a lateral approximant. Thus, [pl] is an acceptable onset in Mong Leng, but [tl] is not. Cantonese and Mandarin both allow a maximum of one C in coda position; however, Mandarin restricts coda C to nasals, while Cantonese allows nasals and oral stops.

There is a universal procedure for syllabification. Although the procedure below is universal, it relies on phonotactics, which varies from language to language. All languages have obligatory nuclei. Normally, this is the only required component of a syllable, although some languages have obligatory onsets, too. In many languages, the nucleus must be a vowel; however, in English, the nucleus can also be a liquid or a nasal. In Blackfoot, an aboriginal language spoken in North America, a nucleus can be either a vowel or /s/. Another universal property of syllable structure is the Maximize Onset Principle. This principle states that consonants prefer to appear in onset position rather than in coda position (recall how much easier it is to say [ba-ba-ba] rather than [ab-ab-ab]). Thus, if you have a consonant or set of consonants between two syllables, it is preferable to place them in the onset of the following syllable rather than in the coda of the preceding syllable, as long as it does not violate the phonotactic constraints of the language to do so.

1. Identify nuclei – obligatory
2. Form onsets → “Maximize Onset Principle”
3. Form codas

Let’s look at an example with the English word *extreme*. The first step is to identify the nuclei. Although liquids and nasals can be the nucleus of the syllable, vowels must be. Also, a nasal cannot be the nucleus if it adjacent to a vowel. A liquid can only in some circumstances. Here are the nuclei for the English word *extreme*.

**Hmong** is a Hmong-Mien language, which is a language family spoken in southern China and south-east Asia. Hmong is a dialect continuum spoken is the very south of China and in neighbouring Vietnam, Thailand and Laos. The Hmong-Mien people have traditionally lived in higher elevations.

Hmong is an isolating SVO language. In contrast to neighbouring languages it distinguishes singular, dual and plural in its pronominal system.

I – kuv 
we two – wb 
we three or more – peb

For an example of Hmong, check out the following link:
http://phonetics.ucla.edu/appendix/languages/hmong/hmong.html
Next, we form the onsets. The rule “Maximize Onset Principle” states that as much material as possible should appear in the onset of the syllable. Note that in English [ɹ], [tɹ], and [stɹ] are all possible onsets, but [kstɹ] is not. Thus, [stɹ] forms the onset of the second syllable.

Finally, we form the codas. Since [k] cannot be a part of the onset of the second syllable, it must be the coda of the first syllable. Of course [m] must be the coda of the second syllable. The nucleus and the coda together form the rhyme, and the rhyme and the onset together form the syllable.

Practice 4.6

Syllabify the following English words. Consult a native speaker of English if you can to verify the pronunciations. There is some variation in the number of syllables in the word *snorkelling*.

- horse
- mechanization
- barbers
- snorkel
- steaming
- temperature
- snorkelling
- reflection
- latchstring

Depending on the phonotactics of the language, further phonological operation may be necessary to syllabify a word. Recall that in Korean there may be a maximum of one C in coda position and one C or one C plus glide in onset position. If there is a sequence of consonants that violates this constraint, then one of the consonants must be deleted according to specific deletion rules in Korean. One such rule is the following, where $ refers to a syllable boundary.
(37) $/ps/ \rightarrow [p] / _$~

Consider, now, the following Korean data. The root $/\dot{aps}/$ means ‘not have’. What is the syllable structure for the phonetic forms? What happened to the /s/ in (38)a? (Note that there is fortition in some of the consonants, identified by an $\ast$. This does not play a role in the questions of syllabification here.)

(38) Phonological form a. $/\dot{aps}-\dot{ja}/$ not.have-DECL b. $/\dot{aps}-\lambda-jo/$ not.have-INFORMAL-POLITE

Phonetic form $[\dot{a}p\dot{t}^\ast a]$ $[\dot{a}p\dot{s}^\ast \lambda jo]$

To answer this question, let us look at the underlying forms and attempt to syllabify them. First we identify the nuclei in the two forms.

\[
\begin{array}{cccccc}
| & | & | & | & | & | \\
\lambda & p & s & \lambda^\ast & a & \lambda & p & s & \lambda & j & o \\
\end{array}
\]

Next, we form the onsets. Again, the rule “Maximize Onset Principle” states that as much material as possible should appear in the onset of the syllable. Note that in Korean only a single consonant can appear in onset position. This gives the following results, so far.

\[
\begin{array}{ccccccc}
| & | & | & | & | & | & | & | & | & | & | & | & | \\
\lambda & p & s & \lambda^\ast & a & \lambda & p & s & \lambda & j & o \\
\end{array}
\]

Finally, we form the codas. Since $[ps]$ is not an acceptable coda in Korean, the deletion rule in (37) applies.

\[
\begin{array}{ccccccc}
| & | & | & | & | & | & | & | & | & | & | & | & | \\
\lambda & p & s & \lambda^\ast & a & \lambda & p & s & \lambda & j & o \\
\end{array}
\]
Practice 4.7

Syllabify the following Ajagbe words given the following syllable constraints (Morley, 2010).

i. The maximum syllable is CAAVN, where A is approximant and N is nasal
iii. [ŋ] can be syllabic, but only if it cannot appear in coda position. It cannot appear in the onset, however.

<table>
<thead>
<tr>
<th>[plen]</th>
<th>‘all’</th>
<th>[flãŋga]</th>
<th>‘flag’</th>
</tr>
</thead>
<tbody>
<tr>
<td>[kŋmɛ]</td>
<td>‘dough’</td>
<td>[ŋɔ̃ʧi]</td>
<td>‘nose’</td>
</tr>
</tbody>
</table>

In the previous section we observed that phonological rules can depend on the properties of neighbouring sounds. Phonological rules can also be sensitive to syllable structure. Consider the following English data, where syllable boundaries are marked with a period. Note the pronunciations indicated are typical of most North American varieties of English, but are less common in varieties spoken in the UK and India. In particular, note the segment, [l], which is called a velarized or dark ‘l’. It is articulated by raising the body of the tongue toward the velum.

(39)  

|-----|------|------|-------|------|-------|---------|----------|

Can you predict the distribution of [l] and [ɫ]? The distribution is predictable, however, it is not determined by neighbouring sounds, but rather by the position of this phoneme in the syllable. When /l/ is in onset position, it surfaces as [l]. When is appears in the rhyme (either in the nucleus or in the coda), it surfaces as [ɫ]. Thus, we can state the distribution of these two allophones informally as follows.

(40)  

/l/ in nucleus or coda position (i.e., in the rhyme position)

/l/ elsewhere

More formally, we can state this as a phonological rule as follows. Note carefully how syllable structure is referred to. Specifically, that part of the syllable in question points to the underscore in the rule.

(41)  

/l/ → [l] /
As a final illustration of how syllable structure can affect phonological rules and play a role in our understanding of the phonological forms, we will consider devoicing in German. Note that in the following data there is a great deal of variation in the shape of the plural marker; however, it plays no role in the discussion. Syllable boundaries are marked with a period. Consider the following data.

(42) Singular          Plural        Genitive

[ʃulp]        [ʃul.pən]        ‘cuttlebone’
[typ]         [tv.pən]        [typs]       ‘type’
[liump]       [lum.pən]        ‘scoundrel’
[hip]         [hi.bə]        ‘blow’
[dip]         [di.bə]        [dips] or [di.bə]   ‘thief’
[zip]         [zi.bə]        ‘sieve’
[flut]        [flu.tən]      ‘flood’
[felt]        [fel.dəʃ]      [felts] or [fel.dəʃ] ‘field’
[ait]         [ai.də]        ‘oath’

Let’s consider the various forms for ‘thief’. It looks as though it is possible to account for the surface forms by assuming a rule of intervocalic voicing as we did for the Korean and Cree data above. However, assuming such a rule is problematic for much of the other data. Consider the following putative derivations for “thief” and “type” based on a rule of intervocalic voicing.

<table>
<thead>
<tr>
<th>Phonological form</th>
<th>/dip/</th>
<th>/dip-ə/</th>
<th>/typ/</th>
<th>/typ-ən/</th>
</tr>
</thead>
<tbody>
<tr>
<td>C → [+voi] / V __ V</td>
<td>--</td>
<td>dibə</td>
<td>--</td>
<td>tvbən</td>
</tr>
</tbody>
</table>

Phonetic form  

[dip]  [dibə]  [typ]  [tvbən] [tuvn] [tuvn] [tuvn] [tuvn] [tuvn] [tuvn] [tuvn] [tuvn] [tuvn] [tuvn] [tuvn] [tuvn] [tuvn] [tuvn] 

Such a rule gives rise to the wrong surface form for the plural of *typ*, so we must look for an alternative explanation. Looking through the data we see that obstruents (all sounds that are [-sonorant]) are always voiceless in coda position. So instead let us explore the possibility that voiced obstruents become voiceless in coda position. Note we must restrict this rule to obstruents since /n/ and /ʁ/ appear in coda position, yet are still voiced. In order for this analysis to work, we must assume that the underlying form for “thief” is /dib/. Here, then, are the derivations with the correct rule. The two genitive forms for “thief” have been added to illustrate the analysis further.
These German data offer another illustration of neutralization (see the discussion on flapping in English above). Although /p/ and /b/ are distinct phonemes in German, this distinction is found only in onset position. In coda position these two sounds neutralize to [p]. Neutralizations in coda position are extremely common cross-linguistically. In Korean the sounds /t̪/, /t̪h/, /t̪ʰ/, /ʧ/, /ʧh/, /ʧʰ/, /s/, and /sʰ/ are contrastive in onset position, but all neutralize to [ɾ] in coda position.

### Practice 4.8

Consider the following Korean data. Syllabify the words according the the rules for syllable structure in Korean given above. What is the distribution of [ɾ] and [ɾ̥] in Korean?

<table>
<thead>
<tr>
<th>Word</th>
<th>Syllabification</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>[maŋiɾ]</td>
<td>‘garlic’</td>
<td></td>
</tr>
<tr>
<td>[rubi]</td>
<td>‘ruby’</td>
<td></td>
</tr>
<tr>
<td>[ŋaɾe]</td>
<td>‘to Seoul’</td>
<td></td>
</tr>
<tr>
<td>[maŋiɾiɾ]</td>
<td>‘garlic-ACC’</td>
<td></td>
</tr>
<tr>
<td>[sauɾiɾ]</td>
<td>‘Seoul’</td>
<td></td>
</tr>
<tr>
<td>[iɾ]</td>
<td>‘one’</td>
<td></td>
</tr>
</tbody>
</table>

### 4.6 Morphophonology

Until now, we have just been looking at the properties of sound systems of language – phonology. We know, however, that phonology interacts with morphology in many ways. The interaction between phonology and morphology is called morphophonology. For instance, certain kinds of allomorphic variation is triggered by phonological properties. We call this phonologically conditioned allomorphy. Consider the following Korean data.

<table>
<thead>
<tr>
<th>(43)</th>
<th>Base noun</th>
<th>Nominative form</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>[saŋwa]</td>
<td>[saŋwaga]</td>
<td>‘apple’</td>
<td></td>
</tr>
<tr>
<td>[koŋi]</td>
<td>[koŋiɾa]</td>
<td>‘meat’</td>
<td></td>
</tr>
<tr>
<td>[miŋho]</td>
<td>[miŋhoɾa]</td>
<td>‘Minho’ (name)</td>
<td></td>
</tr>
</tbody>
</table>
There are two allomorphs for the nominative marker in Korean: [-i] and [-ga]. The choice between these two is triggered by the phonological properties of the base to which it attaches. We can state the insertion frames for the lexical entries as follows.

\[(44)\]
\[
\text{NOM} \leftrightarrow [-\text{ga}] / \_ \_ \text{V} \\
\text{NOM} \leftrightarrow [-\text{i}] / \_ \_ \text{C}
\]

Likewise, the conditioning environment for the allomorph in question may be lexically specified. Recall the German data in (42) above. Observe that there are three plural allomorphs represented in these data. (In reality, there are more plural allomorphs, but we will restrict ourselves to the three in these data.) The choice of allomorphs depends on the root it attaches to, so we call this \textit{lexically-conditioned allomorphy}. Here are the insertion frames for the plural allomorphs in the German data.

\[(45)\]
\[
\text{PL} \leftrightarrow [-\text{on}] / \{\text{ʃulp, tvp, lump, flut}\} \_ \\
\text{PL} \leftrightarrow [-\text{ə}] / \{\text{hib, dib, zib, aid}\} \_ \\
\text{PL} \leftrightarrow [-\text{ɔ}] / \{\text{feld}\} \_
\]

Lexically-conditioned allomorphy is not necessarily sensitive just to roots but also to semantic features of roots. Recall that the choice of classifier in Korean and in Chinese languages is conditioned by various semantic features.

\textbf{Practice 4.9}

Consider the following (slightly simplified) Tarascan data (Foster, 1969). The morpheme /tse/ indicates volitional movement and has two allomorphs. Determine the distribution of these two allomorphs. Is this an example of phonologically-conditioned allomorphy or lexically-conditioned allomorphy?

\[
\begin{align*}
\text{[jɔ-tsi-tas} \text{p}\text{h} \text{eni}] & \quad \text{‘to put a great deal on someone’s table’} \\
\text{[n} \text{i}-\text{tsi-kwareni}] & \quad \text{‘to go all alone’} \\
\text{[xu}-\text{tsi-kwareni}] & \quad \text{‘to come all alone’}
\end{align*}
\]

\[
\begin{align*}
\text{[anta-tse-} \text{nuni}] & \quad \text{‘to be born’} \\
\text{kura-} \text{tse-ni} & \quad \text{‘to be ashamed’} \\
\text{wanta-} \text{tse-ni} & \quad \text{‘to talk about another’}
\end{align*}
\]
Sometimes, however, the actual rules of phonology interact with the rules of morphology. Consider the following European Portuguese data, paying close attention to the plural forms of the masculine definite determiner.

(46)

<table>
<thead>
<tr>
<th>Masculine Definite Determiner</th>
<th>Plural Form</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>u praəu</code></td>
<td><code>uʃ praəu</code></td>
</tr>
<tr>
<td><code>u kwaraq</code></td>
<td><code>uʃ kwaraq</code></td>
</tr>
<tr>
<td><code>u təu</code></td>
<td><code>uʃ təu</code></td>
</tr>
<tr>
<td><code>u kamp</code></td>
<td><code>uʃ kamp</code></td>
</tr>
<tr>
<td><code>u ʃvr</code></td>
<td><code>uʃ ʃvr</code></td>
</tr>
<tr>
<td><code>u ri</code></td>
<td><code>uʃ ri</code></td>
</tr>
<tr>
<td><code>u bark</code></td>
<td><code>uʃ bark</code></td>
</tr>
<tr>
<td><code>u maven</code></td>
<td><code>uʃ maven</code></td>
</tr>
<tr>
<td><code>u ʌu</code></td>
<td><code>uʃ ʌu</code></td>
</tr>
<tr>
<td><code>u ai</code></td>
<td><code>uʃ ai</code></td>
</tr>
</tbody>
</table>

We see here that there are three forms with the following distribution.

(47)

\[
\begin{array}{c}
\text{[uʃ]} / \_ [C +\text{voi}] \\
/\text{uf}/ \\
\text{[uz]} / \_ V \\
\text{[uf]} / \_ [C −\text{voi}] \\
\end{array}
\]

It should be clear by now that should try to discern a natural pattern from this distribution. Note that the consonants in the first two allomorphs are voiced ([ʒ] and [z]). Note further that the triggering environment in both cases contains the feature [+voi]. (Vowels are always voiced unless specified otherwise.) Thus, we can naturally state a voicing assimilation rule as follows.

(48)

\[
/\text{f}/ \to [+\text{voi}] / \_ [+\text{voi}]
\]

We still have to account for the [z] in the second allomorph above, so we need one more rule. Here, we must change the [ʒ] into a [z]. The only difference between these two sounds is the value of the feature [±anterior]. So we come up with the following rule.

(49)

\[
/\text{ʒ}/ \to [+\text{ant}] / \_ V
\]

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Now, the astute reader should have three questions at this point. (1) How did we determine that /uʃ/ is the basic allomorph? (2) The phonological rules, as stated, apply across the board, not just to the morpheme /uʃ/. That is, it predicts that /ʃ/ should always change to [z] when it appears before a vowel—not just in the morpheme /uʃ/. Is the prediction borne out or falsified? (3) Are the rules ordered? Let's answer these questions in order.

Choosing other forms as the basic morpheme yields the following results.

(50)

```
[uz] / _ +voi /G1242C
[uz] / _ V
[uʃ] / _ -voi /G1243
```

(51)

```
[uʒ] / _ +voi /G1242C
[uʒ] / _ V
[uʃ] / _ -voi /G1243
```

In both cases, rules of equal complexity can be formulated, which doesn’t help settle the matter. However, the form /uʃ/ when uttered in isolation surfaces as [uʃ]. Also, when this morpheme is used as a pronoun (meaning ‘them’), it can often appear at the end of a phrase and also surfaces as [uʃ]. So, [uʃ] appear both before voiceless consonants and in phrase-final position (where ψ marks a phrase boundary). Thus, the conditioning environment for [uʃ] is __{[C], ψ}, which does not form a natural class, and so must be stated as the elsewhere case, giving rise to the following actual distribution.

(52)

```
[uʃ] / _ +voi /G1242C
[uʃ] / _ V
[uʃ] / elsewhere
```
The second question requires us to consider additional data. There are several other morphemes with the same distribution as /uʃ/. Here are some examples to show that the phonological rules generalize to other morphemes.

(53)  
[ũʃ praʃ]  ‘some plates’  
[poʊʃ praʃ]  ‘few plates’  
[elgũʃ praʃ]  ‘some plates’  
[mɔʒũʃ praʃ]  ‘many plates’  
[ũʒ lɪvɾuʃ]  ‘some books’  
[poʊʃ lɪvɾuʃ]  ‘few books’  
[elgũʒ lɪvɾuʃ]  ‘some books’  
[mɔʒũʒ lɪvɾuʃ]  ‘many books’  
[ũz ɔʎuʃ]  ‘some eyes’  
[poʊʃ ɔʎuʃ]  ‘few eyes’  
[elgũʒ ɔʎuʃ]  ‘some eyes’  
[mɔʒũʒ ɔʎuʃ]  ‘many eyes’

However, the rules as stated also suggest that they hold inside words and inside morphemes. Consider the following data.

(54)  
[ũmũ]  ‘kick’  
[ũŋref]  ‘chess’  
[ʒɛ̃tũ]  ‘people’

Thus, these rules do not hold inside words. Note, finally that in the data in (46) and (53) that the rules we proposed hold between words or between morphemes. That is because the boundary between the two elements in question is both a word boundary and a morpheme boundary.

[uʒ barkuʃ]  ‘the boats’

#uʒ#barkuʃ#  word boundaries

+uʒ+barku+f+  morpheme boundaries

So, although we are certain that our phonological rules do not operate across the board (since they do not affect the data in (54)), we cannot tell based on the data so far whether they operate at word boundaries only or at morpheme boundaries, too. The following data show clearly that they operate at morpheme boundaries. The phones in question are highlighted in red.

(55)  
[evo]  ‘grandfather’  
[biz+vvo]  ‘great-grandfather’  
[biz+nɛʁu]  ‘great-grandson’  
[pɔʃ+moʃru]  ‘post-modern’  
[pɔʃ+sɨɾəjku]  ‘post-syntactic’  
[tɾɐʃ+poɾtar]  ‘transport’  
[tɾɐʃ+eməzɔɾiku] ‘beyond the Amazon’

We restate the rules as follows.

(56)  
/f/  →  [+voi] / __ + [+voi]

/ʃ/  →  [+ant] / __ + V
Finally, we consider whether the rules need to be ordered or not. Observe that /ʒ/ is the output of the first rule. In order to get the correct output, the two rules must apply in the order shown. To show this, let’s consider the reverse order first.

<table>
<thead>
<tr>
<th>Phonological form</th>
<th>/uʃ praʃuf/</th>
<th>/uʃ lirvuf/</th>
<th>/uʃ ɔʎuʃ/</th>
</tr>
</thead>
<tbody>
<tr>
<td>/ʒ/ → [+ant] / __ + V</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>/ʃ/ → [+voi] / __ + [+voi]</td>
<td>--</td>
<td>uʒ lirvuf</td>
<td>uʒ ɔʎuʃ</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Phonetic form</th>
</tr>
</thead>
<tbody>
<tr>
<td>[uʃ praʃuf]</td>
</tr>
</tbody>
</table>

Observe that we get the wrong result with the rules as stated in the order above. If we reverse the order of the rules, the we get the right result.

<table>
<thead>
<tr>
<th>Phonological form</th>
<th>/uʃ praʃuf/</th>
<th>/uʃ lirvuf/</th>
<th>/uʃ ɔʎuʃ/</th>
</tr>
</thead>
<tbody>
<tr>
<td>/ʃ/ → [+voi] / __ + [+voi]</td>
<td>--</td>
<td>uʒ lirvuf</td>
<td>uʒ ɔʎuʃ</td>
</tr>
<tr>
<td>/ʒ/ → [+ant] / __ + V</td>
<td>--</td>
<td>--</td>
<td>uʒ ɔʎuʃ</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Phonetic form</th>
</tr>
</thead>
<tbody>
<tr>
<td>[uʃ praʃuf]</td>
</tr>
</tbody>
</table>

**Advanced:**

The astute reader will note that we could change the rules above slightly so that they need not be ordered. Subsequent research in phonology has questioned the need for rule ordering. For this text, we will stick to the notion that rule ordering is necessary, but let's take a quick look at how these rules could be altered to make rule ordering unnecessary. One proposal is to assume that rules apply simultaneously. In this case, we could simply change the rules as follows.

(57)  
ʃ/ → [+voi] / __ + [+voi]  
ʃ/ → [+ant] / __ + V

Or, we could change the rules to apply to all postalveolar fricatives only.

(58)  
[+sib] → [+voi] / __ + [+voi]  
[−ant] → [+voi] / __ + [+voi]
As a final illustration of the interaction between morphology and phonology, consider the following Plains Cree data (Ahenakew, 1987). There are two lexically-conditioned allomorph for the plural morpheme. /-a/ is the plural marker for inanimate nouns and /-ak/ is the plural marker for animate nouns. (Recall that in many cases the noun classes are arbitrary.) Our task is to determine the phonological forms of the roots and to determine what noun class they belong to (animate or inanimate). There is also a locative morpheme in these data (a morpheme meaning ‘in’ or ‘on’). What is the phonological form of this morpheme? Does it have any allomorphs? Finally, we need to determine what phonological rules are necessary to account for these data.

(59) [awaːsis] ‘child’ [awaːsisak] ‘children’
[maskisin] ‘shoe’ [maskisina] ‘shoes’
[asikan] ‘sock’ [asikanak] ‘socks’
[oːteːnaw] ‘town’ [oːteːnawa] ‘towns’
[mistik] ‘tree’ [mistikwak] ‘trees’
[atim] ‘dog’ [atimwak] ‘dogs’
[waːpos] ‘rabbit’ [waːposwak] ‘rabbits’
[pahkeːkin] ‘tanned hide’ [pahkeːkinwa] ‘tanned hides’
[asikanihk] ‘in a sock’ [maskisinihk] ‘in a shoe’
[mistikohk] ‘in a tree’ [pahkeːkinohk] ‘on a tanned hide’

Looking at the first four lines, we see that the addition of the plural suffix does not present any difficulties.

Thus, we propose that the phonological forms for the first four roots are as follows.

<table>
<thead>
<tr>
<th>Root</th>
<th>Allomorph</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>awaːsis</td>
<td>+ak</td>
<td>‘child’</td>
</tr>
<tr>
<td>maskisin</td>
<td>+a</td>
<td>‘shoe’</td>
</tr>
<tr>
<td>asikan</td>
<td>+ak</td>
<td>‘sock’</td>
</tr>
<tr>
<td>mistikohk</td>
<td></td>
<td>‘in a tree’</td>
</tr>
</tbody>
</table>

Thus, we propose that the phonological forms for the first four roots are as follows:

/awaːsis/ animate ‘child’
/maskisin/ inanimate ‘shoe’
/asikan/ animate ‘sock’
The next four items, however, present a small challenge. Notice that there is a \([w]\) in the plural forms.

\[ \text{[mistik}wak] \]
\[ \text{[atim}wak] \]
\[ \text{[wa:pos}wak] \]
\[ \text{[pahke:kin}wa] \]

Now, we have to ask ourselves how this \([w]\) came to be here. Is it inserted phonologically? Are \([wak]\) and \([wa]\) two additional allomorphs of the plural morpheme? Is it part of the root? If we list the segments to the left of the plural morphemes with and without the additional \([w]\) we get the following.

<table>
<thead>
<tr>
<th>root + plural</th>
<th>root + w + plural</th>
</tr>
</thead>
<tbody>
<tr>
<td>s</td>
<td>k</td>
</tr>
<tr>
<td>n</td>
<td>m</td>
</tr>
<tr>
<td>w</td>
<td>s</td>
</tr>
<tr>
<td>n</td>
<td>n</td>
</tr>
</tbody>
</table>

We see that these environments overlap, so it doesn’t look like a phonological explanation can be pursued. Also, some of the roots are animate and some are inanimate, as indicated by the plural marker. It might be the case that there are four allomorphs of the plural morpheme and that the \([w]\) is simply part of the plural marker. If we look at the examples with the locative markers, though, we see a correspondence.

\[ \text{[asikan}+ihk] \]
\[ \text{[maskisin}+ihk] \]
\[ \text{[mistik}+ohk] \]
\[ \text{[pahke:kin}+ohk] \]

The forms that appear with the locative suffix \([ohk]\) are the same forms that have the mysterious \([w]\) in the plural. The forms with \([ihk]\) lack this \([w]\). Thus, it seems that certain roots trigger the appearance of the additional \([w]\) and the \([ohk]\) allomorph. Let us propose the following phonological forms for the four roots where the additional \([w]\) is found.

\(/\text{mistikw}/\) animate ‘tree’
\(/\text{atimw}/\) animate ‘dog’
So, it is not the appearance of the [w] in the plural forms that is mysterious...it is the absence in the singular forms that we must account for. If we simply assume that a word-final [w] deletes, then we predict the wrong form for the Plains Cree word for ‘town’. Let’s look at the final segment in the root for the words in which the word-final [w] deletes and for the words in which it does not delete.

<table>
<thead>
<tr>
<th>word-final [w] deletes</th>
<th>word-final [w] does not delete</th>
</tr>
</thead>
<tbody>
<tr>
<td>k</td>
<td>a:</td>
</tr>
<tr>
<td>m</td>
<td></td>
</tr>
<tr>
<td>s</td>
<td></td>
</tr>
<tr>
<td>n</td>
<td></td>
</tr>
</tbody>
</table>

Thus, the word final [w] deletes only if it is preceded by a consonant. Here is the rule.

(60)   /w/ → Ø / C __ #

Finally, we must account for the observed allomorphy in the locative suffix. Although you may be able to think of alternative (and perfectly valid!) explanations based on the data given, it turns out that the sequence /wi/ in Plains Cree regularly changes to [o] in all contexts. Thus, the rule is stated as follows.

(61)   /wi/ → [o]

Since this rule applies in all contexts, we do not state a context. Also, these rules do not interact, so no ordering needs to be worked out. Here is the derivation for some of the forms above.

<table>
<thead>
<tr>
<th>Phonological form</th>
<th>/atimw/</th>
<th>/atimw+ak/</th>
<th>/mistikw+ihk/</th>
</tr>
</thead>
<tbody>
<tr>
<td>/w/ → Ø / C __ #</td>
<td>atim</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>/wi/ → [o]</td>
<td>--</td>
<td>--</td>
<td>mistikohk</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Phonetic form</th>
<th>[atim]</th>
<th>[atimwak]</th>
<th>[mistikohk]</th>
</tr>
</thead>
</table>
### Key Concepts

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>phoneme</td>
<td>The smallest segmental unit of sound employed to form meaningful contrasts between utterances</td>
</tr>
<tr>
<td>allophone</td>
<td>The surface form of a phoneme whose distribution is predictable.</td>
</tr>
<tr>
<td>phone</td>
<td>A discrete sound in a word that acts as a unit.</td>
</tr>
<tr>
<td>phonological feature</td>
<td>A phonologically active property of a phoneme that corresponds to some articulatory property.</td>
</tr>
<tr>
<td>nominative</td>
<td>The case borne by the subject in many languages, including English.</td>
</tr>
<tr>
<td>accusative</td>
<td>The case borne by the direct object in many languages, including English.</td>
</tr>
<tr>
<td>dative</td>
<td>The case borne by the indirect object in many language, but not in English. Indirect objects in English bear accusative case.</td>
</tr>
<tr>
<td>active voice</td>
<td>The form of a sentence in which the thematic arguments correspond to their grammatical counterparts in terms of position.</td>
</tr>
<tr>
<td>passive voice</td>
<td>The form of a sentence in which the thematic object is the grammatical subject.</td>
</tr>
<tr>
<td>structural Case</td>
<td>Case that is assigned by virtue of an arguments position in the structure.</td>
</tr>
<tr>
<td>inherent Case</td>
<td>Case that is assigned directly by a particular lexical item (usually a verb). Typically, inherent Case is dative in German.</td>
</tr>
</tbody>
</table>

### Further Reading

- **Chomsky & Halle (1968)**: This is the earliest formal description of the phonology of English. Many of the concepts introduced here are still used today.
- **Keenan, E. (1985)**: This book chapter provides an overview of passive constructions in the world’s languages.
This comprehensive review paper offers an in-depth discussion of the properties of the *ba-* construction in Mandarin and also gives a brief comparison with a similar construction in Taiwanese Chinese. Much of the descriptive content should be accessible by this point.

### Exercises

1. The following sets of phonemes are natural classes in English. What is the minimal feature set needed to capture each of these natural classes?

   a. ɪ u ʊ
   b. i i e æ e
   c. i e u o a
   d. i e
   e. p t k f 0 s ʃ ʧ h
   f. b f v w
   g. m n ŋ
   h. p b t d k g ʧ dʒ

2. Consider the following Kiowa data (tones omitted). Examine the high tense vowels [i] and its lax counterpart [ɪ]. Are they separate phonemes or allophones of the same phoneme? How about [u] and [ʊ]. Write a general rule that accounts for both alternations. Note that nasalization does not play a role here.

   
   [bɪmkʰɔj]  ‘bag’
   [ji]  ‘two’
   [bɔni]  ‘see’
   [kʻul]  ‘lie’ (plural subject)
   [ougu]  ‘pour’
   [xeqon]  ‘dog’

   [ɡɔn]  ‘dance’
   [jɪge]  ‘four’
   [pʻi]  ‘sister’ (of a female)
   [tʰõuse]  ‘bones’
   [toonei]  ‘say’
   [kʰmei]  ‘long’

3. Consider the following Temne data. Are [t] and [ʧ] allophones of the same phoneme or distinct phonemes? How about [s] and [ʃ]? If they are distinct phonemes, give the appropriate evidence. If they are allophones of the same phoneme write a general rule that accounts for both cases. Note that [t̪] does not play a role here.

   kʌʧim  ‘to fight’
   kʌfənt  ‘the bed’
   dɔjɔ  ‘fool’

   kʌtəma  ‘to stand up’
   tamatb  ‘five’
   der  ‘a face’

   dɔjɔ  ‘a face’
Consider the following Ajagbe data. Are [s] and [ʃ] allophones of the same phoneme? If they are allophones of the same phoneme state the distribution. If they are separate phonemes give appropriate evidence.

<table>
<thead>
<tr>
<th>Ajagbe</th>
<th>Phoneme</th>
</tr>
</thead>
<tbody>
<tr>
<td>[asi]</td>
<td>‘cat’</td>
</tr>
<tr>
<td>[zovi]</td>
<td>‘Azove’ (place name)</td>
</tr>
<tr>
<td>[ezo]</td>
<td>‘fire’</td>
</tr>
<tr>
<td>[sa]</td>
<td>‘sell’</td>
</tr>
<tr>
<td>[kloʒɪn]</td>
<td>‘egg’</td>
</tr>
<tr>
<td>[泽ɛdɛka]</td>
<td>‘directly’</td>
</tr>
</tbody>
</table>

Consider the following Korean data. What is the prefix for marking female animals in Korean? What phonological effect does this prefix have? State the phonological change as a rule. Remember * is used to indicate a fortis consonant in Korean.

<table>
<thead>
<tr>
<th>Korean</th>
<th>Phoneme</th>
</tr>
</thead>
<tbody>
<tr>
<td>[kɛ]</td>
<td>‘dog’</td>
</tr>
<tr>
<td>[tweedʒi]</td>
<td>‘pig’</td>
</tr>
<tr>
<td>[jak]</td>
<td>‘chicken’</td>
</tr>
<tr>
<td>[k*afʰi]</td>
<td>‘magpie’</td>
</tr>
<tr>
<td>[mal̪]</td>
<td>‘horse’</td>
</tr>
</tbody>
</table>

Now consider the following Welsh data. The possessive prefix looks the same for all three possessive forms; however, they are actually different. State the three possessive prefixes and give the phonological rule necessary for each prefix, if necessary.

<table>
<thead>
<tr>
<th>Welsh</th>
<th>Phoneme</th>
</tr>
</thead>
<tbody>
<tr>
<td>porteth</td>
<td>‘their’</td>
</tr>
<tr>
<td>pledau</td>
<td>‘pluen’</td>
</tr>
<tr>
<td>tafel</td>
<td>‘kefal’</td>
</tr>
</tbody>
</table>