FILE 4.4

How to Solve Phonology Exercises

Because phonemes are important units of linguistic structure, linguists must have a general method for identifying them in all languages. But the task of determining what the phonemes of a language are and what allophones are assigned to them is not always straightforward. For one thing, the set of phonemes differs from language to language, and so a different analysis is required for each language. Moreover, phonemes are psychological units of linguistic structure and are not physically present in a stream of speech. As a result, it is not possible to identify the phonemes of a language simply by taking physical measurements on a sample of language. Nor is it always easy to identify phonemes by investigating a native speaker's intuitions, since the minute phonetic details on which decisions about phonemes are made are often precisely those which speakers are not accustomed to noticing.

To get around these problems, linguists have developed an objective procedure by which the phonemes of a language can be discovered through examination of a set of words written in phonetic transcription. This procedure is based on the following observations about patterns of sounds:

a. **Phonemes** make distinctions in meaning. If two sounds are members of separate phonemes, minimal pairs can almost always be found. For example, the minimal pair *led* and *red* is evidence that [l] and [r] are members of separate phonemes in English. But if two sounds are allophones of the same phoneme, minimal pairs differing only in those sounds will not exist. For example, [bʌʔn̩] and [bʌtʰn̩] are both possible pronunciations of the English word *button* (though [bʌtʰn̩] may sound a little stilted). This is because the sounds [ʔ] and [tʰ] are both allophones of the phoneme /t/. Thus, the meaning doesn't change.

b. The **allophones** of a phoneme are not a random collection of sounds but are a set of sounds that have the same psychological function. Accordingly, allophones of the same phoneme are systematically related to one another:

i. They share many phonetic properties.
ii. It is possible to predict which allophone will appear in a word on the basis of phonological rules.

By analyzing the patterns of sounds that are physically present, it is possible to draw conclusions about the psychological organization of a language, which is not directly observable.

4.4.1 How to Do a Phonemic Analysis

Although a phonemic analysis can be performed successfully on any language, it is easiest to begin with a problem based on English, since we already know in effect what the solution is. Look over the data below, which are given in a fairly narrow phonetic transcription:

pray	[pʰr̥eɪ]	fresh	[fr̥ɛʃ]
gray	[greɪ]	regain	[rigeɪn]
crab	[kʰr̥æb]	shriek	[ʃr̥ik]
par	[pʰar]	tar	[tʰar]
broker	[broʊkr̩]		

Beginning with the sounds [r] and [r̥], we attempt to answer the following question: are these sounds allophones of separate phonemes, or allophones of the same phoneme? (Of course, native speakers of English intuitively know that they are allophones of the same phoneme. However, the procedure for doing a phonemic analysis should produce the same answer without appealing to the intuitions of speakers.)

In order to answer this question, it is necessary to examine scientifically the **distribution** of sounds within these data. That is, for each sound in question we need to determine the set of phonetic environments in which it can occur. But just what do we mean by "environment"? For the time being, we can define the **environment** of a sound as the sounds that immediately precede and follow it within a word. For example, in the word [greɪ], [r] is in the environment [g_eɪ]; that is, [r] is preceded by [g] and followed by [eɪ].

The best way to begin a phonemic analysis is to determine whether the sounds in question are contrastive. To do this, look first for minimal pairs. Suppose for a moment we were interested in the sounds [pʰ] and [tʰ] in the data above. These sounds do appear in a minimal pair: [pʰar] and [tʰar] have different meanings and differ phonetically by only a single sound in the same position. This tells us that [pʰ] and [tʰ] are in overlapping distribution and, more specifically, that they are in contrastive distribution, because the difference between them causes a difference in meaning. Therefore, they are allophones of different phonemes.

Returning to the problem at hand, namely, the status of [r] vs. [r̥], we see that there are no minimal pairs in the data that differ only by these two sounds. Since [r] and [r̥] are not in overlapping distribution in our data, we can assume that they are in complementary distribution. However, we must prove that this is so by making a generalization about where [r] (but not [r̥]) may appear, and vice versa. In order to do so we need to compare the phonetic environments of each of these sounds. The easiest way to do this is to make a list for each sound, as follows. (Note that "#" indicates a word boundary.)

[r]	[r̥]
[g_eɪ]	[pʰ_e]
[a_#]	[kʰ_æ]
[b_oʊ]	[f_ɛ]
[#_i]	[ʃ_i]

Once you have collected the list of phonetic environments for each sound, it is necessary to proceed as follows:

1. *Look at the environments to find natural classes.* [r̥] is preceded by [pʰ], [kʰ], [f], and [ʃ], all of which are voiceless consonants. This generalization permits us to simplify the description of the environment for [r̥]; instead of listing each sound separately, it is now possible to say:

[r̥] appears after voiceless consonants.

Now look at the environments in which [r] appears. Are there any natural classes? Yes and no. Certainly [b] and [g] are voiced consonants, and [a] is also voiced, but the set that includes [b], [g], [a], the beginnings of words, and the ends of words does not form a natural class. Thus, the critical observation to make here is that there is no single natural class of environments in which [r] can be found.

We have looked at the sounds preceding [r] and [r̥], but what about the sounds that follow them? As you can see, only [r] may occur word-finally, but either [r] or [r̥] can occur before a vowel. Thus, the environments that condition the appearance of [r] or [r̥], i.e., the conditioning environments of these particular allophones, are their immediately preceding sounds.

2. *Look for complementary gaps in the environments.* So far, we have shown that [r̥] appears after voiceless consonants, while [r] appears in an apparently random set of environments. Yet, it is possible to make one more critical observation. [r] does not appear in the environments in which [r̥] appears, namely, after voiceless consonants. Moreover, [r̥] does not appear where [r] does; there is no [r̥] after voiced consonants or at the beginnings and ends of words. Since the environments of [r] and [r̥] have systematic and complementary gaps, we say that [r] and [r̥] are in complementary distribution. Therefore, they are allophones of the same phoneme.

3. *State a generalization about the distribution of each of these sounds.* In other words, write a rule that will make predictions about where each of the sounds can occur. Actually, we've done the hard part of this already by observing that [r̥] occurs following voiceless consonants. How should we state the distribution of [r]? We could try formulating our rule as follows:

[r̥] appears following voiceless consonants;
[r] appears following voiced consonants or vowels, or at the beginning or end of a word.

However, that's not a very succinct formulation of the rule. To simplify it, recall that wherever [r̥] occurs, [r] can't, because their possible environments form complementary sets. Therefore, we can revise our rule this way:

[r̥] appears following voiceless consonants;
[r] appears elsewhere.

4. *Determine the identity of the phoneme and its allophones.* This next step in writing the rule involves deciding what the phoneme to which these sounds belong should be. In order to do so, we need to decide which of the allophones is the **basic allophone** and which is the **restricted allophone**. We have determined that the conditioning environment for [r̥] consists of a single natural class of sounds. [r̥] is restricted to occurring only there, whereas [r] may appear anywhere else. Therefore, we can identify [r̥] as the restricted allophone and [r] as the basic one. It makes sense to name the phoneme after the basic allophone, since it is the one that can show up in a wider variety of contexts. Furthermore, the basic allophone is assumed to be the closest approximation of the mental "sound" that speakers store in memory. In choosing a name for the phoneme, we have made the leap from observable phonetic reality to unobservable psychological reality. (It is not always possible to choose one allophone as basic, however. In that case the phonology exercise's instructions will not tell you to do so, and any of the allophones would serve equally well as the name of the phoneme.)

We can improve on our rule once more. The arrows in the rule below mean "is pronounced as." We use slashes around symbols that represent phonemes and a single slash indicates the beginning of the environment specification:

/ r / → [r̥] / after voiceless consonants;
/ r / → [r] / elsewhere.

Now that we have formulated the necessary phonological rule, we can see which phonological process it involves (cf. File 4.3). In this rule a voiced phoneme changes into a voiceless sound when it follows another voiceless sound. In other words, /r/ becomes more like a preceding sound with respect to the feature of voicelessness. Therefore, we can conclude that the process of assimilation is involved in this phonological rule.

4.4.2 Some Potential Trouble Spots

The procedure outlined in the previous section will work for any language for which reliable phonetic transcriptions exist. However, beginners are often confused by certain questions.

For instance, if you discover that no minimal pairs exist for two sounds, is it possible to automatically conclude that they are allophones of the same phoneme? No. It is still necessary to show that the sounds are in complementary distribution, since allophones are predictable variant pronunciations of the same phoneme.

Consider what happens if you make a decision too soon. Using the data presented at the beginning of the previous section, suppose you wanted to know whether [g] and [ʃ] are allophones of the same phoneme. Since there are no minimal pairs differentiated by these sounds, it might seem reasonable to conclude that they are. (Of course, a speaker of English should have no trouble thinking of a minimal pair involving these two sounds. However, the data you will be given in phonology exercises will be sufficient for you to solve those problems.) But a careful examination of the data reveals that this is the wrong conclusion. Listing the data and the relevant environments, you find:

[g] appears in *gray* [greɪ], *regain* [rigeɪn]
generalization: [g] appears between vowels or at the beginning of a word;
[ʃ] appears in *fresh* [fr̥ɛʃ], *shriek* [ʃr̥ik]
generalization: [ʃ] appears at the beginning or end of a word.

As these data illustrate, [g] and [ʃ] are not in complementary distribution because their distributions overlap: either may occur at the beginning of a word. As a result, no phonological rule can be responsible for their distribution. In general, when *no generalization* can be made about where a group of sounds can occur, it is possible to conclude that they are members of separate phonemes. A conclusion based on such a demonstration is just as valid as showing that minimal pairs exist. This alternative way of showing that sounds are members of separate phonemes is useful because it's not always possible to find minimal pairs for all distinctive sounds. For example, there are no minimal pairs involving [ŋ] and [h] in English. But it is reasonable to assume that they belong to separate phonemes because they share few phonetic properties, and no phonological rule determines where they can occur.

The range of tests for identifying phonemes can be broadened somewhat by the use of **near-minimal pairs**. Recall that a minimal pair is a pair of words differing in meaning but phonetically identical except for one sound in the same position in each word. The definition of near-minimal pairs is the same, except that the words are *almost* identical except for the one sound. For example, *heard* [hr̩d] and *Bert* [br̩t] form a near-minimal pair involving [h] and [b]. We are justified in saying that [h] and [b] are allophones of separate phonemes because no conceivable phonological rule would permit only [h] at the beginnings of words ending in [d], and only [b] at the beginnings of words ending in [t].

One final point about minimal pairs: notice that we have not defined them as pairs of words that rhyme. It is not necessary for two words to rhyme in order to form a minimal pair. Consider English *state* [steɪt] and *steak* [steɪk], for example, or *boat* [boʊt] and *beat* [bit].

Nor is rhyming sufficient to qualify a pair of words as a minimal pair: *gray* [greɪ] and pray [pʰr̥eɪ] from the list of data above rhyme, but differ in two sounds. And to take another example, *glitter* and *litter* rhyme but do not form a minimal pair because they do not contain the same number of sounds.

Another question that often troubles beginners is this: when describing the environment in which a sound appears, how do you know where to look? In the problem we solved in the previous section, we considered only the sounds that preceded [r] and [r̥]. This is certainly not the only possibility. In fact, identifying conditioning environments is the most challenging part of doing a phonemic analysis.

Recall that in the previous section we temporarily defined the environment of a sound as the sounds immediately surrounding it. However, it is sometimes necessary to look beyond the sound's immediate environment. For instance, if you are examining the distribution of a vowel allophone, it is quite common that the conditioning environment involves a vowel in an adjacent syllable, even though consonants may intervene. It may also be necessary to consider preceding or following sounds even when they belong to another word that is adjacent in the stream of speech. However, it is best to start by examining the immediate environment of an allophone when you are trying to determine what its conditioning environment is.

Since there are many logically possible environments to consider, the task is made easier by eliminating all of those except the most plausible. This can be accomplished by using strategies like the following:

a. *Formulate hypotheses about the allophones.* Investigation of the world's languages has revealed that some sounds are more common than others (see File 4.7 for relevant discussion). For example:

- Voiced nasals and liquids are more common than voiceless ones.
- Oral vowels are more common than nasal vowels.
- Consonants of normal length are more common than long consonants.
- "Plain" consonants are more common than those with secondary articulations like velarization, palatalization, and labialization.

On the basis of these generalizations, it is possible to speculate that if a less common sound appears in a language, it is probably a restricted allophone. But these tendencies should be used only as a guide for forming hypotheses, not as a basis for jumping to conclusions, since some languages exhibit exceptions. For example, French has both nasal and oral vowel phonemes.

b. *Keep in mind that allophonic variation results from the application of phonological rules.* Also remember that rules usually involve some phonological process, such as assimilation or deletion. Once you have a hunch about which allophone is the restricted one, check the environment in which it appears for evidence that a phonological process has applied. This may involve looking in more than one place until you have discovered a reasonable candidate. In the problem in the previous section, we were guided by the knowledge that voicing differences in consonants are often caused by voicing assimilation, and that voicing assimilation frequently occurs in consonant clusters. Since /r/ is the second member of all of the clusters given, we concluded that the consonant preceding it constituted the conditioning environment. Even if it is not obvious that a phonological process has been at work, you should be able to write a phonological rule and, thus, state a generalization about where the allophones of the phoneme occur.

4.4.3 Flowchart for Discovering the Distribution of Sounds

The flowchart should help you to identify the type of distribution two (or more) sounds in a language have. The rectangular boxes ask you to do something or give you some information that your working through the flowchart has revealed. The diamond-shaped boxes pose a question. Try reading through the flowchart before you attempt to analyze the languages in the next file; it may help you to understand the relationship between the different types of distributions of sounds in a language.