Week 1. Phonemic analysis

I. Introduction

1. What is phonology?

Phonology is the system of rules, representations, and principles governing the distribution of sounds.

2. Why study phonology?

- Sounds often vary considerably based on context. This variation is usually not arbitrary, but follows predictable patterns (which are often complex) which need to be figured out.

For example, the voiceless alveolar oral stop /t/ has several different realizations in English:

i. voiceless aspirated stop in the onset of stressed syllables and word-initially:
   - ‘imitation’ [ɪmətʃən], ‘terrific’ [təˈrɪfɪk]
ii. flaps intervocalically before a stressless vowel or syllabic consonant: ‘city’ [sɪrɪ]
iii. unreleased or glottalized in word-final position: ‘sat’ [sæt] or [sæʔt],

- One of the most interesting aspects of phonology is that despite its often complex nature, children learn the phonology of their native language(s) quite easily.

- Phonology also interacts with other aspects of linguistic study including morphology, syntax, and sociolinguistics; learning about the phonology can provide insights into these other areas.

II. Phonemic Analysis

3. Phonemic analysis involves two things:

   - Establishing the set of phonemes in a language.
   - Figure out the phonological rules that determine the environments where allophones occur.

4. Some basic concepts of phoneme analysis

- **Phoneme** = a basic speech sound which is used for distinguishing or contrasting one word from another.

  e.g. /z/ and /s/ are phonemes of English since they are used to differentiate words:
  - ‘zip’ /zip/ vs. ‘sip’ /sɪp/

- This pair of words is a **minimal pair**, since the words differ in exactly one sound in the same place in the word.

  /zip/ and /sip/ is not a minimal pair, nor is ‘seal’ /sɛl/ and ‘eels’ /ɪlz/.
We know that /z/ and /s/ are phonemes, though, because we were able to find a minimal pair in at least one environment, at the beginning of words.

5. Sometimes accidental gaps in the vocabulary of a language make it impossible to find minimal pairs illustrating that two sounds are separate phonemes

For example, it is incredibly difficult to find minimal pairs for English /ð/ and /ʒ/.

Some dialects have the following minimal pairs:

'bathe' /bɵ/ vs. ‘beige’ /bɵʒ/
'leather’ /leðɪ/ vs. ‘leisure’ /leʒɪ/
‘seethe’ /sið/ vs. ‘siege’ /siʒ/

But, alot of speakers realize these pairs as:

/bɵ/ vs. /bɵʒ/
/leðɪ/ vs. /leʒɪ/
/sið/ vs. /siʒ/

For these speakers, there are no minimal pairs.

But, there are a lot of near-minimal pairs for all speakers:

‘tether’ /teðɪ/ vs. ‘pleasure’ /pleʒɪ/
‘smaaoothen’ /smuðæn/ vs. ‘fusion’ /fjuʒæn/
‘heathen’ /hiðæn/ vs. ‘adhesion’ /ædˈhiʒæn/

• Near-minimal pairs are minimal except for irrelevant differences which could not plausibly be influencing the sounds which are potential phonemes.

For example, there is no plausible difference between /niðɪ/ and /siʒɪ/ (or for the other near minimal pairs above) which could be responsible for the difference between /ð/ and /ʒ/.

In other words, there is no plausible and consistent rule which we could write to explain why we get /ð/ in /teðɪ/, /smuðæn/, and /hiðæn/ but [ʒ] in /pleʒɪ/, /fjuʒæn/, and /ædˈhiʒæn/

If, we can’t write a reasonable and consistent rule to explain the occurrence of a sound, then it is a separate phoneme.

6. Every phoneme has multiple variant realizations depending on context (as we saw above for /t/ in English).

**Allophone** = contextually determined variant of a phoneme

The phoneme /t/ has several allophones in English, each one occurring in a different environment (they are in complementary distribution, meaning they never occur in the same environment).

7. Another example of allophones in English: the phoneme /l/ has several allophones.
Generalizations:
- [θ] occurs word-finally
- [ɫ] occurs when the preceding consonant is voiceless
- [t] occurs when the following sound is [θ]
- [l] occurs when none of the other conditions are met

These variants of are, of course, in complementary distribution, i.e. they never occur in the same environment.

9. Formalizing the relationship between phonemes and allophones

- Phonemic transcription is written in slashes / /.
- Phonetic (allophonic) transcription is written in brackets [ ].

Often, when we want to be neutral about whether a sound is its own phoneme or an allophone of another phoneme we also use brackets [ ].

For example, if we are looking at data for the first time and don’t know yet whether a sound is a phoneme or an allophone:

- Slash means “in the environment”
- A long underline stands for the place where the allophone occurs relative to its neighbors
  / __ \word means “in the environment immediately before the end of a word”

10. The mapping between an underlying phoneme and its surface allophones is a rule or derivation

Example: Rule of word-final velarization in English

/ɛ/ → [θ] / __ \word

means “the phoneme /ɛ/ becomes (goes to) [θ] in the environment __ \word

11. Often, there is a class of sounds involved in the description

In this case, we use features to define the class

Example: The allophone [ɫ] occurs after a voiceless consonant

/ɛ/ → [ɫ] / [ ubiquitous
  +voiceless _ ]
The sound which occurs to the left of the arrow is the underlying phoneme, while the sound to the right of the arrow is the allophone.

12. How do you decide which sound is the underlying phoneme and which are the surface allophones?

The underlying phoneme is usually the sound which occurs in the elsewhere environment, i.e. in the most diverse set of environments. For example, in the above example from English, /l/ is the underlying phoneme.

13. Some sample derivations in English

<table>
<thead>
<tr>
<th>‘slight’</th>
<th>‘plow’</th>
</tr>
</thead>
<tbody>
<tr>
<td>/slai/t</td>
<td>/plau/</td>
</tr>
</tbody>
</table>

Underlying form (=phonemic transcription)

Rules:

<table>
<thead>
<tr>
<th>slai/t</th>
<th>plau</th>
</tr>
</thead>
<tbody>
<tr>
<td>/l/ devoicing</td>
<td></td>
</tr>
<tr>
<td>s[slai/t]</td>
<td>[plau]</td>
</tr>
</tbody>
</table>

Surface form (=allophonic/phonetic transcription)

— means that a rule is not applicable

14. Allophones often have a phonetic motivation (more on this later)

- For example, the [l] allophone may be the result of coarticulation with the preceding voiceless sound (coarticulation is a type of ease of articulation)

- The dental [l] also may be attributed to coarticulation with the following dental sound.

- It is unclear, however, what the phonetic motivation is for the dark [l] occurring word-finally (It is interesting to note though that English is not the only language with this sound)

15. A sound which is a phoneme in one language may be an allophone in another language. Conversely, a sound which is an allophone in one language may be a phoneme in another.

16. Consider the case of the flap [r] in North American English:

The flap is an allophone of /t/ in North American English.

Roughly, the rule is as follows (subject to modification in chapter 3)


<table>
<thead>
<tr>
<th>‘city’</th>
<th>‘sit’</th>
</tr>
</thead>
<tbody>
<tr>
<td>/siti/</td>
<td>/sit/</td>
</tr>
</tbody>
</table>

Underlying form

Rules:

<table>
<thead>
<tr>
<th>s[iti]</th>
<th>[sit]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flapping</td>
<td></td>
</tr>
</tbody>
</table>

Surface form
17. /t/ and /ɾ/ are separate phonemes in Spanish, as demonstrated by minimal pairs like /pata/ ‘paw, foot (of animal)’ vs. /para/ ‘for’

18. Now, consider the case of the sounds [ð] and [d] (remember, we use brackets here because we are still just talking about the sound neutrally and not making a commitment (yet) about whether it is a phoneme or an allophone)

/ð/ and /d/ are separate phoneme in English, because they contrast with other sounds in a given environment
e.g. ‘die’ /dai/ vs. ‘thi’ /ðai/, ‘den’ /dən/ vs. ‘then’ /ðən/, ‘bayed’ /bed/ vs. ‘bathe’ /beð/

In Spanish, however, [ð] and [d] are allophones of the same phoneme

[ð] occurs after a vowel, while [d] occurs elsewhere (=after consonants and initially)
[daðo] ‘given’
[deðo] ‘finger’
[usteð] ‘you (polite)’
[onde] ‘where’
[de ðonde] ‘from where’

We set up /d/ as the underlying phoneme since it occurs in the elsewhere environment and then posit a rule of spirantization (change from stop to fricative)

/d/ → [ð] / [+vowel] __

<table>
<thead>
<tr>
<th>/dedo/</th>
<th>/onde/</th>
<th>Underlying form</th>
</tr>
</thead>
<tbody>
<tr>
<td>deðo</td>
<td>—</td>
<td>Spirantization</td>
</tr>
<tr>
<td>[daðo]</td>
<td>[onde]</td>
<td>Surface form</td>
</tr>
</tbody>
</table>

19. We can work backwards to get the underlying (phonemic) form if we know the rule and the surface form
e.g. given what we know about spirantization in Spanish, we can figure out the underlying form for the surface form [laðo]; the underlying form is /lado/

20. We can check this by setting up applying spirantization to the underlying form /lado/ to see if we wind up with the correct form [laðo]

<table>
<thead>
<tr>
<th>/lado/</th>
<th>Underlying form</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rules:</td>
</tr>
<tr>
<td>iaðo</td>
<td>Spirantization</td>
</tr>
<tr>
<td>[iaðo]</td>
<td>Surface form</td>
</tr>
</tbody>
</table>

21. Some additional notes on rules:

22. When we write a rule using features, the only features which change are those occurring to the right of the arrow.
For example, the rule of spirantization in Spanish discussed earlier is really a more general rule applying to all voiced stops, not just /d/:

\[ (+\text{stop}) \quad \rightarrow \quad (+\text{fricative}) \quad /\quad (+\text{vowel}) \quad _{\_} \quad \]

(Note that these are just tentative features; we will talk more about features soon)

The only feature which changes is the manner feature (+stop) which becomes (+fricative). In other words, the feature (+voice) stays the same. Similarly, any other features automatically associated with stops also stay the same.

23. Rules which apply to groups of sounds, e.g. spirantization of voiced stops in Spanish, apply to **natural classes** of sounds, i.e. sounds which have in common one or more feature values

24. Rules usually change only one or two features rather than completely changing all features. For example, spirantization only turns the stop into a fricative; it does not change voicing, nasality, consonantality, or any other features all at the same time.

25. Likewise, the environment of a rule usually also forms a natural class sharing one or more features.

   For example, the rule of /l/ devoicing in English occurs in the environment following the natural class of voiceless consonants

26. **More on natural classes**

27. A natural class of sounds is a **complete** set of sounds sharing a feature or set of features.

   In order to know whether sounds form a natural class in a language you need to know if they form a complete set.

   /p/ and /k/ are not a natural class in English, since English has a third voiceless oral stop /t/.

   /p/ and /k/ are a natural class in Hawaiian, though, because Hawaiian has no /t/.
28. Exercise on natural classes

Imagine a language with the following sounds:

\[ p \ t \ k \ b \ d \ g \ m \ n \ \eta \ l \ i \ e \ a \ o \ u \]

Which of the following sets of sounds form a natural class? For those which do form a natural class, state what the class is.

a. \([t, d, n, l]\)

b. \([b, d, g]\)

c. \([b, d, k]\)

d. \([i, o, u]\)

e. \([p, t, k, b, d, g]\)

f. \([m, n, \eta, l]\)

g. \([b, g]\)

h. \([b, d, g, m, \eta]\)

29. More on phonemes and allophones

As we have seen, sounds which are in complementary distribution are allophones.

30. What happens though if a rule changes a set of sounds in a certain environment?

In this case, there is more than one sound in complementary distribution with the underlying phoneme in the same environment.

For example, the rule of Spanish spirantization applies to all voiced stops.

\[
\begin{align*}
\text{[+stop]} & \rightarrow \text{[+fricative]} / \text{[+vowel]} \quad [\text{+voice}]
\end{align*}
\]

This means that the voiced stops \([b, d, g]\) occur in one set of environments, the elsewhere environments, whereas the fricative \([\beta, \delta, \gamma]\) occur in another environment, after vowels.

31. The problem is that \([b]\) is in complementary distribution with not only \([\beta]\) but also with \([\delta]\) and with \([\gamma]\). Similarly, \([d]\) is in complementary distribution with \([\beta, \delta, \gamma]\). Likewise, \([g]\) is in complementary distribution with \([\beta, \delta, \gamma]\).
32. Looking at the rule, it may seem pretty clear that [β] and not [ð] or [ɣ] is an allophone of [b], and that [ð] and not [β] or [ɣ] is an allophone of [d], and that [ɣ] and not [β] or [ð] is an allophone of [g].

33. *But, imagine we’re just looking at data and we haven’t figured been given the rule.*

34. In this case, the criterion of **phonetic similarity** comes into play. The most similar sound to [b] is [β] since it differs only in terms of manner of articulation and not in terms of place also. Similarly, the most similar sound to [d] is [ð] and the most similar sound to [g] is [ɣ].

35. Furthermore, it is common for **native speaker intuitions** to indicate that allophones belonging to the same phoneme are the “same” sound.

36. Most speakers do not notice differences between sounds which are allophones of the same phoneme, but they are very aware of differences between phonemes.

37. Most English speakers would never think of the two types of [t] as being different; indeed phonetically, they are quite similar.

38. In Bengali, however, alveolar /t/ and dental /t̪/ are contrastive. 

   /tan/ ‘(vocal) tune’ vs. /tan/ ‘pull!’
   /sat/ ‘seven’ vs. /sat/ ‘sixty’

39. Even though they are phonetically quite close, Bengali speakers would consider them completely different and would probably clearly notice the difference in English between the dental [t] in ‘eighth’ and ‘ate the’ and the alveolar one in ‘ate food’.

40. **More on criteria of phonetic similarity and native intuitions.**

41. In English, [h] and [ŋ] are in complementary distribution:

   [h] occurs at the beginning of words and before stressed syllabic sounds

   hill  [hɪl]
   high  [hɑɪ]
   ahead  [əhæd]
   prohibit  [pəˈhɪbɪt]
   rehearse  [rɪˈhɑːrs]
[ŋ] occurs at the end of words, before consonants and between syllabic sounds of which the second is stressless

- sing [sɪŋ]
- sink [sɪŋk]
- hangs [hæŋz]
- singer [sɪŋɡə]
- Singapore [ˈsɪŋɡəpɔːr]

42. Are [h] and [ŋ] allophones of the same phoneme?

   No, why not?

43. Because they are not phonetically similar and because native speakers do not feel that they belong to the same phoneme.

44. **Contextually-Limited Contrast**

45. So far, we have seen rules that change an underlying phoneme into a surface allophone.

46. There are also rules which do not actively change sounds but which are static constraints on where underlying phonemes may occur.

   For example, in English words ending in two stops, the second stop must be alveolar

   - concept ['kænsəpt]
   - ripped ['rɪpt]
   - robbed ['robd]
   - contact ['kɒntækt]
   - milked ['mɪlktd]
   - begged ['bɛgd]

   *[ˈkænsɛpt]*
   *[ˈrobd]*
   *[ˈkɒntækt]*
   *[ˈbɛgd]*

47. This is a general principle of English that can be formalized as a rule

<table>
<thead>
<tr>
<th>Alveolar Place Enforcement</th>
</tr>
</thead>
<tbody>
<tr>
<td>[+stop] → [+alveolar] / [+stop] ___ word</td>
</tr>
</tbody>
</table>

48. So, although there is a three-way place contrast (/p, t, k/) among English stops in most environments, there is no contrast in word-final position after another stop.
49. This is a **contextually-limited contrast**, since the phonemic contrast is limited to certain contexts.

50. Many contrasts are contextually limited

e.g. Three-way contrast among /m, n, ŋ/ is limited to a two-way contrast in word-initial position in English.

   e.g. Obstruent clusters in word-final position in English must agree in voicing

   \[
   \begin{align*}
   \text{apt \[æpt\]} & \quad *\text{æpt}, *\text{æpd} \\
   \text{clasp \[klæsp\]} & \quad *\text{k\læsb}, *\text{k\læzp}
   \end{align*}
   \]

51. **Optional rules**

52. Many rules do not apply obligatorily; rather they are optional

   e.g. Glottalization of final voiceless stops in English

   \[
   \begin{align*}
   [+\text{stop}] & \rightarrow [+\text{constricted glottis}] / \_ \_ \_ \_ \_ \text{word} \\
   +\text{voice} & 
   \end{align*}
   \]

53. When this rule applies, we get, for example, \[sæ\text{t}\]; when it doesn’t apply, we get \[sæt\]

54. We can say then that regular [t] and glottalized [t] are in free variation with each other in final position, meaning we can get either variant depending on the particular token

55. As it turns out, for most rules, optionality depends on social context. For example, optional rules tend to be suppressed in formal or slow speech, but are more likely to apply in casual or rapid speech.

   For example, flapping for many English speakers can even be suppressed in very careful speech

56. **Explaining why we get allophones and how languages choose the “elsewhere” allophone**

57. The “elsewhere” allophone (i.e. the underlying phoneme) is generally the one which is perceptually most salient and which is perceptually most distinct from other phonemes.

58. The other allophones are generally the result of considerations of ease of articulation

59. **An example: English oral and nasal vowels**

60. For example, English underlying vowels are all oral. Before nasal consonants, vowel are nasalized.

61. Oral vowels are perceptually more distinct from each other than nasalized vowels, since nasalization obscures formant structure; for this reason, oral vowels are better basic phonemes than nasalized vowels.
62. However, in front of a nasal consonant, it is articulatorily easier to start lowering the velum during the vowel in anticipation of the following nasal (the velum is a large and slow articulator); this leads to nasalization of the vowel.

63. Thus, considerations of articulatory ease compete with (and win out over) considerations of perceptual distinctness in prenasal position.

64. Similarly, devoicing of /l/ after voiceless consonants in English is natural from an articulatory standpoint; the glottis is wide open for the preceding voiceless consonant and it is hard to close it enough to allow for voicing by the time the /l/ begins.

65. In fact, articulatory ease can lead to **neutralization** of underlying contrasts, where a contrast is not just made perceptually less distinct but is completely eliminated.

Example, final devoicing of stops (natural because of the loss of subglottal air pressure in final position) in German leads to neutralization of underlying contrasts

/ʃat/ → [ʃat] ‘advice’
/ʃad/ → [ʃat] ‘wheel’

66. Languages tend to exert more effort in places where the perceptual distinctiveness between sounds is greatest.

67. For example, in many languages, nasals assimilate in place to a following oral stop

    e.g. /Vm/tV/ → [VntV]  
        /VŋtV/ → [VmtV]  
        /VnpV/ → [VmpV]  
        /VŋpV/ → [VmpV]  
        /Vm/kV/ → [VŋkV]  
        /VnkV/ → [VŋkV]

68. This makes sense for articulatory reasons; it’s easier not to have to change the oral articulators.

69. **But**, why not change the oral stop to the place of the nasal?

    e.g. /Vm/tV/ → [VmpV]  
        /VŋtV/ → [VŋkV]  
        /VnpV/ → [VntV]  
        /VŋpV/ → [VŋkV]  
        /Vm/kV/ → [VmpV]  
        /VnkV/ → [VntV]

70. **Reason:** prevocalic consonants are perceptually more distinct from each other than consonants which are not followed by a vowel.
71. Thus, in order to satisfy conditions on articulatory ease, languages often “sacrifice” the consonant which is already worse off perceptually (the non-prevocalic consonant) and save the perceptually more robust consonant.

72. **A Caution**

73. **Allophonic rules are not just automatic physical effects**

74. How do we know this?

    • Not all languages apply the same rules even though speakers of all languages have pretty much the same speech organs

    For example, not all languages assimilate nasals to the place of the following consonant

    • For those languages that have them, rules apply even in very slow speech, where physical factors driving articulatory ease are not so important

    This shows that a consistent and coherent grammar is important; languages are not slaves to physical considerations

    • Whether an allophonic rule applies or not may be determined by the structure of the language

    Here is the reasoning:

    a. For example, in most languages, low vowels are at least slightly longer than high vowels (probably because, lower vowels involve jaw lowering which requires more time since jaw is a large articulatory).

    b. In some languages, low vowels can be almost twice as long as high vowels (to the point where they attract stress in the stress system)

    c. It happens that in most languages with huge differences between low and high vowels, there is no contrast between short and long vowels, e.g. no minimal pairs like /pa:ta/ vs. /pata/

    d. Because there is no length contrast, low vowels can safely undergo substantial lengthening without jeopardizing the perceptual salience of the length contrast

    e. In languages with a length contrast, low vowels can not lengthen much, though, because of the length contrast.

    *If low vowel lengthening were purely physically-driven, then it would not matter if the language has contrastive long vowels or not.*