Handout #1

Complementary and contrastive distribution
Distribution

• The distribution of a sound category in a language is the set of positions it can occupy in an utterance.

• Part of what you know when you know a language is a rich system of restrictions on distribution.

• This system is called phonology, and that is also the name for the study of such restrictions.
Voiceless stops in English

• There are two kinds of voiceless plosive stops in English:
  – Aspirated voiceless stops \([p^h, t^h, k^h]\)
  – Unaspirated voiceless stops \([p, t, k]\)
• Each of the two classes is restricted to a particular set of mutually exclusive contexts.
Aspirated and unaspirated voiceless stops

• The aspirated stops are produced with the vocal folds maximally far apart, allowing maximal airflow through the glottis.

• The voiceless unaspirated stops are produced with the vocal folds apart enough and stiff enough that they don’t vibrate, but not as far apart as in the aspirated stops.
Aspirated and unaspirated voiceless stops

• During the closure step of a plosive, there is little acoustic energy produced.
• A sharply defined closure gap in energy can be seen in a spectrogram.
• When a plosive is released, the air rushes out of the mouth so rapidly that airflow is turbulent.
• The acoustic result is noise - unorganized aperiodic energy.
Aspirated and unaspirated voiceless stops

• The noise burst is longer in an aspirated stop than in an unaspirated stop.
• This is because airflow is greater, due to the greater glottal width.
• Greater airflow leads to higher oral pressure in the aspirated stop, which leads to a longer and more intense burst.
tie [tʰai] - die [dai] - sty [stai]
Voiceless stops in English

- **Pam**  \([\text{p}^\text{hæm}]\)  \(\text{spam}\)  \([\text{spæm}]\)
- **tone**  \([\text{t}^\text{houn}]\)  \(\text{stone}\)  \([\text{stoun}]\)
- **Kate**  \([\text{k}^\text{heɪt}]\)  \(\text{skate}\)  \([\text{skeɪt}]\)
- **pop**  \([\text{p}^\text{hæp}]\)  \(\text{tart}\)  \([\text{t}^\text{hæt}]\)
- **kick**  \([\text{k}^\text{ɪk}]\)  \(\text{appeal}\)  \([\text{ə}^\text{p}^\text{hɪl}]\)
- **retire**  \([\text{r}^\text{e}.\text{thæl}]\)  \(\text{recall}\)  \([\text{r}^\text{e}.\text{k}^\text{hæl}]\) (Period marks syllable boundary)
Voiceless aspirated stops occur only at the beginning of a syllable.
Voiceless unaspirated stops occur only elsewhere.

This is a complementary distribution.
Two classes of sounds are in complementary distribution if there is a context such that one class only occurs there and the other class can’t occur there.
Complementary distribution

• For English speakers, aspirated \([p^h]\) and unaspirated \([p]\) seem like slightly different versions of the same sound.
• This is despite the fact that they are physically just as different as \([p]\) and \([b]\).
• But speakers do consistently produce them in the appropriate place, and they notice if someone (e.g. a non-native speaker) doesn’t do so.
Complementary distribution

• The distribution is automatic and holds for all words of English.
• Speakers obey it even in speech errors - a native speaker never slips up by saying *top* as [tɒp] or *stop* as [stʰɑp].
• English speakers follow this distribution when they speak other languages with other distributions, e.g. Spanish *peso* [ˈpeso] pronounced by Americans as [ˈpʰeɪˌsoʊ].
Contrastive distribution

• Two sounds are in contrastive
distribution if they aren’t in complementary
distribution.

• The contexts in which two such sounds can
occur are not mutually exclusive.
  – For example, the stops \([p^h, t^h, k^h]\) can occur in
    exactly the same context, at the beginning of a
    word before the sequence \([\text{æd}]\):
  – \(pad [p^{h\text{æd}}] \quad tad [t^{h\text{æd}}] \quad cad [k^{h\text{æd}}]\)
Contrastive distribution

- A **minimal pair** is a pair of two words that differ in just one sound, i.e. you can turn one word into the other by replacing just one sound.
  - *pad* [pʰæd]  *tad* [tʰæd]

- If two sounds distinguish a minimal pair, they must be in contrastive distribution.
Contrastive distribution

• Sounds that are in contrastive distribution can distinguish words.

• Sounds that are in complementary distribution with each other can never be the difference between two words, since they could never occur in the same place in a word.
Contrastive distribution

- Speech perception is about distinguishing what word is being produced.
- That’s the task listeners are focused on.
- Thus the differences between two sounds in contrastive distribution are salient to speakers.
- English speakers don’t have to be taught to distinguish $[p^h, t^h, k^h]$. 
Phonological analysis

- The complementary distribution of aspirated and unaspirated voiceless stops in English is just as statement of distribution - what sounds occur where.

- A phonological analysis is a psychological model of what a speaker knows about speech categories, including their distribution.
Phoneme

- Part of the phonological analysis is a set of phonemes.
- A phoneme is a set of sounds that are in complementary distribution with each other, all of which are treated by speakers as belonging to the same category.
- English phonemes: \([p^h, p], [t^h, t], [k^h, k]\)
- The sounds that are members of a phoneme are called **allophones** of that phoneme.
Phoneme

- The phoneme can include different sounds, indicated by different phonetic symbols.
- But the phoneme is denoted by the default allophone - the sound that occurs “only elsewhere”.
- The phoneme is distinguished by slanted braces: /p/, /t/, /k/. 
A phoneme is not a sound.
It’s a psychological category that is instantiated by sounds.
Two sounds belonging to different phonemes (e.g. \([p^h, t^h]\)) are perceived as being clearly different from each other.
Two sounds belonging to the same phoneme (e.g. \([p^h, p]\)) are perceived as being the same, even if they are quite distinct physically.
Phoneme

• If two sounds are in contrastive distribution, they must belong to different phonemes.
• \([p^h, t^h, k^h]\) are in contrastive distribution with each other, so they must belong to three different phonemes.
• The same is true of \([p, t, k]\).
• There must be three voiceless stop phonemes in English: /p, t, k/. 
Phonological analysis

• The set of phonemes gives the default forms of every phone (actual physical speech sound) in the language.
• The other, nondefault forms are indicated in the analysis by phonological rules, which change one phonological representation into another.
Phonological rules

• A phonological rule must state:
  – What class of sounds it applies to (in this case, voiceless stops)
  – How the output differs from the input (in this case, it becomes aspirated)
  – The context in which this restriction applies (in this case, at the beginning of a syllable).
The aspiration rule

• Aspiration rule:
  – Change a voiceless stop into an aspirated one if it occurs at the beginning of a syllable.

• So the phonological analysis for the sounds $[p^h, t^h, k^h, p, t, k]$ consists of this rule, and the set of phonemes: /p, t, k/.
Phonological representations

- The **underlying representation** of a morpheme or word consists just of phonemes.
- Phonological rules apply to the underlying representation.
- The output of all the rules is called the **surface representation** - it is the phonetic transcription.
# A derivation

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<th>Underlying representation</th>
<th>Aspiration rule</th>
<th>Surface representation</th>
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Derivations

- A **derivation** illustrates for a particular word or phrase the mapping from underlying representation to surface form.
  - The first line of the derivation is the underlying representation.
  - The last line is the surface representation.
  - In between, each line gives the output of a rule.
  - If the rule makes no change to an item, this is indicated by a blank on that line for that item.
Basic rules for phonological analysis

• If two sounds are in contrastive distribution, they must belong to different phonemes.

• If two sounds are in complementary distribution:
  – One of them (the one with the restricted distribution) is not a phoneme, and must be created by a phonological rule.
  – This rule changes the default allophone (the phoneme) into the restricted allophone in the context where the restricted allophone occurs.
Phonological distributions across languages

• The distribution of voiceless stops in English is not physically necessary.
• In other languages with the same sounds, the distribution is quite different.
• As a result, the way speakers treat these sounds differs from language to language.
• Languages differ not only in what sounds they have, but also in how those sounds are distributed.
Korean

• In Korean (Sohn 1999), the aspirated voiceless stops are in contrastive distribution with the unaspirated ones:
  – [kʰɨn] “big” [kɨn] “a pound”

• Thus in Korean, the two kinds of voiceless stop must belong to different phonemes:
  – /pʰ, tʰ, kʰ, p, t, k/
Korean

• Physically, these voiceless stops in Korean are quite similar to the ones in English.
• But because the aspirated and unaspirated stops belong to separate phonemes in Korean, speakers feel them to be quite distinct.
Writing systems

• Writing systems that encode sounds usually reflect phonemes rather than phones.
• The goal is to convey which word you mean to use, and only phonemes can distinguish words.
• Accordingly, aspirated stops are distinguished from unaspirated ones in Korean writing, but not in English.
References