# 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.

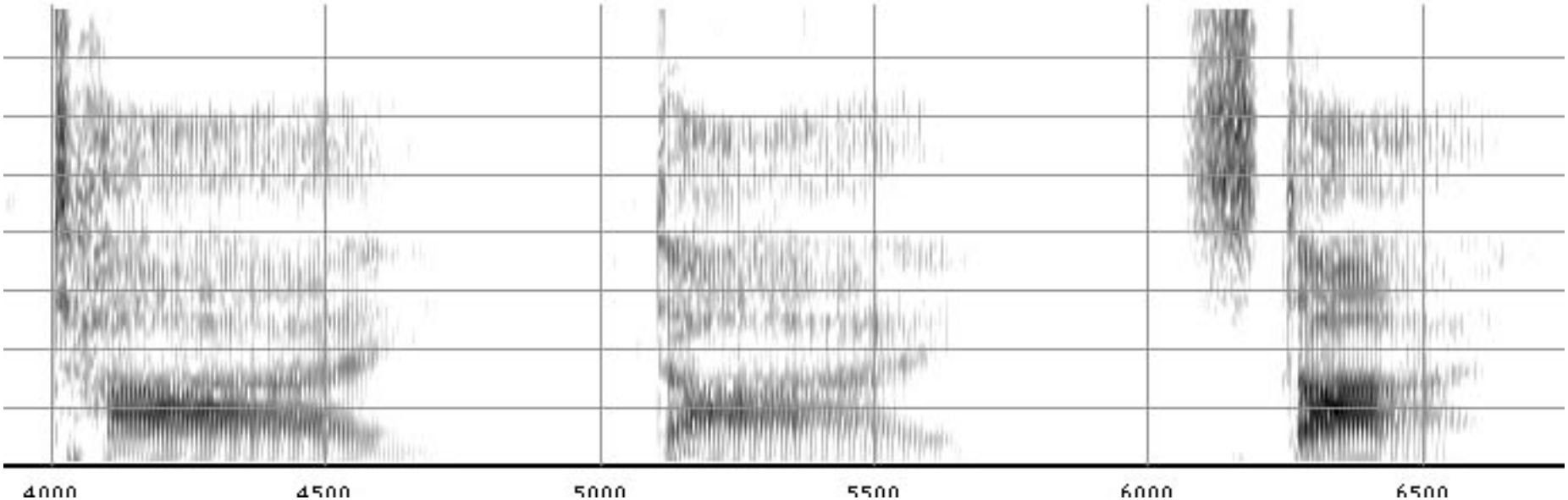
# Aspirated and unaspirated voiceless stops

- 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* [tʰaɪ] - *die* [daɪ] - *sty* [staɪ]



# Voiceless stops in English

- *Pam* [p$^{h}$æm] *spam* [spæm]
- *tone* [t$^{h}$oʊn] *stone* [stoʊn]
- *Kate* [k$^{h}$eɪt] *skate* [skeɪt]
- *pop* [p$^{h}$ɑp] *tart* [t$^{h}$ɑɹt]
- *kick* [k$^{h}$ɪk] *appeal* [ə.p$^{h}$il]
- *retire* [ɹə.t$^{h}$aɪɹ] *recall*
  [ɹə.k$^{h}$ɑl] (Period marks syllable boundary)

# Distribution

- 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 [tɑp] or *stop* as [st$^{h}$ɑp].
- English speakers follow this distribution when they speak other languages with other distributions, e.g. Spanish *peso* [ˈpeso] pronounced by Americans as [ˈp$^{h}$eɪˌsou].

# 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 [æd]:
  - *pad* [**$p^h$**æd] *tad* [**$t^h$**æd] *cad* [**$k^h$**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* [p$^{h}$æd]  *tad* [t$^{h}$æd]
- 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/.

# Phoneme

- 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

| | | |
|---|---|---|
| Underlying representation | /pɑt/ | /spɑt/ |
| Aspiration rule | /$p^h$ɑt/ | ------ |
| Surface representation | [$p^h$ɑt] | [spɑt] |

# 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:
  - [$p^h$ul] “grass” [pul] “fire”
  - [$t^h$əl.da] “shake off” [təl.da] “reduce”
  - [$k^h$ɨn] “big” [kɨn] “a pound”
- Thus in Korean, the two kinds of voiceless stop must belong to different phonemes:
  - /$p^h$, $t^h$, $k^h$, 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


- Sohn, Ho-Min (1999). *The Korean Language*. Cambridge University Press, Cambridge.