# Acoustics of Speech and Hearing

Lecture 2-7

Speech Perception Testing

## Overview

- Why do we need perception tests?
- Types of test
- Running a test
- Analysis of test results
- Examples

## What is a perception test?

- Experimental procedure to find which aspects of the signal are used by listeners in decoding speech
  - either to find out more about the signal
  - or to find out more about the listener
- Typically ask listeners to identify a word or to discriminate between pairs of words.
- Often use synthetic or manipulated speech signals to get control over exact sound

## Finding out more about the signal

- Studying spectrograms only raises hypotheses for acoustic cues
  - Need to know what aspects of the spectrographic pattern listeners actually use
- Multiple cues to any contrast
  - Need to know which cues are most important
- Building a speech processing system
  - Need to know if contrasts affected

## Finding out more about the listener

- Tests on normal listeners
  - language development, individual differences, L2 learners, bilingualism, ...
- Tests on disordered listeners
  - effect of hearing impairment on communication
  - phonological disorder/delay
  - differentiate types of impairment (peripheral/central)

## Word Intelligibility Tests

- To obtain an overall measure of subject performance in listening to speech
- Standard lists
  - e.g. PBK (phonetically-balanced kindergarten) lists
  - e.g. BKB sentence lists
- Mark % words identified correctly
- Compare across signal conditions
  - e.g. dBSPL, SNR, type of hearing aid
- Compare with normative results
  - e.g. by chronological age

ball
bear
bike
bird
boat
bus
cake
clock
coat
comb
cup
dog
door
dress

## Phoneme-level Testing

- Not always easy to use word intelligibility to find out about specific cues or contrasts
- Influence of higher linguistic levels:
  - knowledge of possible words
  - frequency of possible words
  - likelihood of words in context
- In some situations, better to focus on individual phonemes

## Two types of phoneme test

1. Analyse how phonemes are confused with each other
   - Ask listeners to identify phonemes, e.g. syllables presented in poor listening conditions so as to force errors
   - look for patterns among the errors: what are common phoneme confusions?

CONFUSIONS

2. Analyse how a single acoustic cue affects one contrast
   - Generate some artificial sounds with manipulated values of some acoustic cue, e.g. /ba/ changing to /pa/ with VOT
   - Ask listeners to choose between two phonemes
   - Analyse how different values of the cue affects choice

CONTRAST

## Type 1: Phonemic Confusions

- E.g. Miller & Nicely experiment, 1955
- VCVs played to listeners under many different conditions of SNR and filtering
- Listeners choose from 1 of 16 consonants only
- "Confusion matrix" shows how often each consonant was confused with others
- Analysis shows confusions about place more common than confusions about voicing

## Example confusion matrix

TABLE V. Confusion matrix for $S/N = +6$ db and frequency response of 200–6500 cps.

| | p | t | k | f | θ | s | ʃ | b | d | g | v | ð | z | ʒ | m | n |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| p | 162 | 10 | 55 | 5 | 3 | | | | | | | 1 | | | | |
| t | 8 | 270 | 14 | | | | | | | | | | | | | |
| k | 38 | 6 | 171 | 1 | | | | | | | | | | | | |
| f | 5 | 1 | 2 | 207 | 57 | | | 3 | | | 1 | | | | | |
| θ | 5 | 1 | 2 | 71 | 142 | 3 | | | | | 2 | 2 | | | | |
| s | | 1 | | 1 | 7 | 232 | 2 | | | 1 | | | | | | |
| ʃ | | | | | | 1 | 239 | | | | | | | | | |
| b | | | | 1 | 2 | | | 214 | | | 31 | 12 | | | | |
| d | | | | | | | | | 206 | 14 | | 9 | 1 | 2 | | |
| g | | | | | | | | 11 | 64 | 194 | | 4 | 2 | 1 | | |
| v | | | | 1 | 1 | | | 14 | | 2 | 205 | 39 | 5 | | | 1 |
| ð | | | | | | | | 2 | | 4 | 55 | 179 | 22 | 2 | | |
| z | | | | | | | | | 3 | 10 | 2 | 20 | 198 | 3 | | |
| ʒ | | | | | | | | | 3 | 4 | | | 2 | 215 | | |
| m | | | | | | | | | | | | | | | 217 | 3 |
| n | | | | | | | | | 1 | | | | | | 2 | 285 |

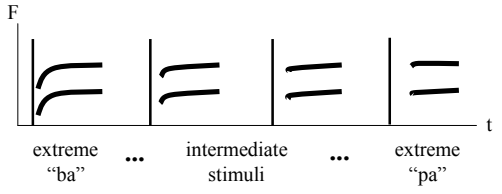
Miller & Nicely, "An analysis of perceptual confusions among some English consonants", J. Acoust.Soc.Am, 27 (2), 1955, 338-352.

## Type 2: Phonemic Contrast

- e.g. Lisker & Abramson VOT experiment, 1967
- Used to investigate how one particular cue is used by listeners to discriminate between phoneme categories
- Synthetic CVs varying only in Voice Onset Time are played to listeners
- Listeners choose b/p, or d/t or g/k only
- Analysis shows how CVs fall into two clear categories along the VOT dimension

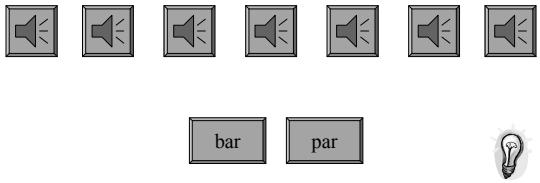
## Example Stimuli

- Voice Onset Time /bɑ/ - /pɑ/
  - vary VOT across continuum



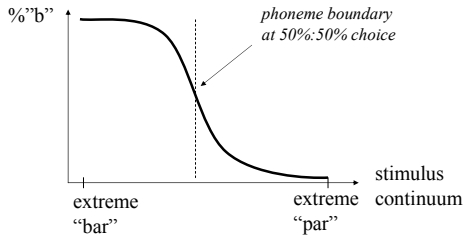
## Running an identification test

- Multiple, random presentations of each stimulus
- Record forced choice responses



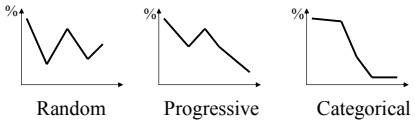

## Analysis of test results

- Labelling graph



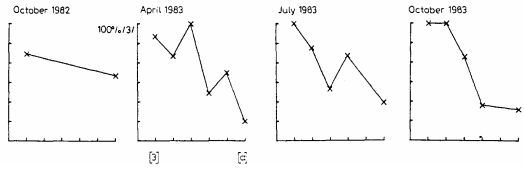

## Analysis of test results

- Describe labelling behaviour




- Estimate phoneme boundary
- Estimate confidence from steepness

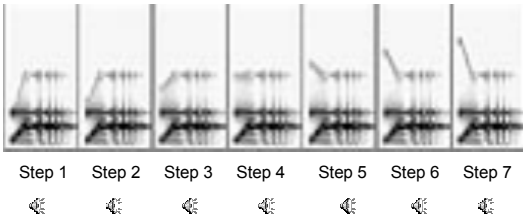
## Tracking Development




- For this subject, performance on a task developed over 12 months
- As task becomes easier, stimuli are labelled more reliably and curve becomes steeper at boundary

## Other example contrasts

/r/ - /l/ continuum

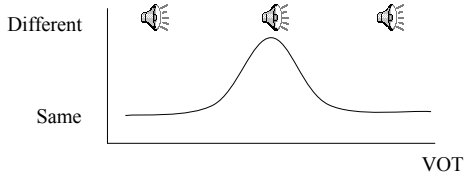



## Other example contrasts

- Spectral peak frequency
  - /ʃɑ/ to /sɑ/
- F2 Locus Frequency
  - /bæ/ - /dæ/ - /gæ/
- Voice Onset Time
  - /bɑː/ - /pɑː/, /dɑː/ - /tɑː/, /gɑː/ - /kɑː/

## Discrimination Tests

- Judgements of similarity rather than identification of phonological category
- Used to show how perceptual system adapts to aid identification of language-specific categories




## Summary

- Why do we need speech perception tests?
  - find out about signal vs. find out about listener
  - overall word intelligibility vs. phonetic detail
  - phonetic confusions vs. phonetic contrast
- Design of phonetic tests and stimuli
- Running of tests and analysis of results

## Lab Experiment

- Two Perceptual experiments
  - Phonetic confusions in noise
  - Labelling of VOT dimension
- We'll do listening task first
- Then stimuli will be explained
- Then you'll analyse your own performance
- We'll also calculate a class average