Language ≠ Speech

- Speech is the preferred modality for language.
Auditory cortices bilaterally
Questions

- Is speech special?
  - Can brain damage lead to a selective loss of speech perception?
  - Are the mechanisms of speech perception different from the mechanisms of auditory perception in general?
    - Role of audio-visual integration
Disorders of auditory processing

- Rare.
- Signal from each ear is processed in both hemispheres (contra visual system).
- Bilateral damage often necessary.
  - Generally requires two separate neurological events.
Disorders of auditory processing:

CORTICAL DEAFNESS

- Inability to hear sounds without apparent damage to the hearing apparatus.
- Extensive bilateral damage to auditory cortex (BAs 41 & 42).
Disorders of auditory processing:
AUDITORY AGNOSIA

- Inability to recognise auditorily presented sounds (e.g., coughing, crying) independent of any deficit in processing spoken language.
- Damage in auditory association cortex (BAs 22 & 37)
Disorders of auditory processing:
AMUSIA (a subvariety of AUDITORY AGNOSIA)

- Impaired in tasks requiring pattern recognition in music.
- Relative sparing of speech and (other) non-speech perception.
- Damage generally in right temporal areas.
- Controversial.
Disorders of auditory processing:

PURE WORD DEAFNESS

- Inability to understand spoken words while
  - auditory perception is otherwise intact &
  - other linguistic skills are intact (reading, speech production)
Disorders of auditory processing:

PURE WORD DEAFNESS

Either

- Bilateral damage to auditory cortex

Or

- A subcortical lesion severing both ipsilateral and contralateral projections to auditory areas
  (Ziegler, 1952; Geschwind, 1965; Coslet et al., 1984; Jones and Dinolt, 1952).
Disorders of auditory processing:

PHONAGNOSIA

- Impairment in the ability to recognise familiar voices.
  - Speech comprehension is intact.
  - Intact ability to identify nonverbal sounds.
Disorders of auditory processing:

PHONAGNOSIA

- Van Lancker et al., 1988: Double dissociation between memory for familiar voices and the ability to discriminate between unfamiliar voices.

- Performance on a discrimination task was impaired by a lesion to either temporal lobe.

- Performance on the famous voices task was impaired by lesions to the right parietal lobe.
Questions

- Is speech special?
  - Can brain damage lead to a selective loss of speech perception? **YES, but no one-to-one correspondence between lesion site and type of disorder. E.g., bilateral temporal damage can lead either to cortical deafness or pure word deafness.**
  - Are the mechanisms of speech perception different from the mechanisms of auditory perception in general?
    - Role of audio-visual integration
Questions

- Is speech special?
  - Can brain damage lead to a selective loss of speech perception? YES, but no one-to-one correspondence between lesion site and type of disorder. E.g., bilateral temporal damage can lead either to cortical deafness or pure word deafness.
  - Are the mechanisms of speech perception different from the mechanisms of auditory perception in general?
    - Role of audio-visual integration
McGurk effect
Role of articulatory gestures on speech perception

- When the visual image of a person saying “ga” is combined with an audio recording of “ba”, the percept is “da” (or for some people “ga”).

- Incongruent articulatory gestures can change the auditory percept even when the signal is clear.
Is audio-visual integration specific to speech?

  - **Audio–visual integration of the “plucks” and “bows” of cello playing.**
    - Not only speech, but also other ecologically valid combinations of auditory and visual stimuli can integrate in a complex manner.

- Tuomainen et al. (2004, *Cognition*): Audio-visual integration is used in speech much more than in the perception of other sounds.
  - **Investigated the effect of incongruent articulatory gestures on speech vs. nonspeech, utilizing the ambiguous status of so-called sine-wave speech.**
**Sine-wave speech**

A spectrogram, or an acoustic "picture" of a speech utterance. Time is represented on the horizontal axis, frequency on the vertical axis. Amplitude corresponds to the darkness.

A sinewave replica of the natural above. All fine-grain acoustic properties of speech are discarded and only the coarse-grain changes in the spectra over time are retained.
Sine-wave speech

Remez et al. (1981):

- Naïve subjects fail to perceive sine-wave stimuli as speech.
- However, if subjects are instructed about the speech-like nature of sinewave speech, they can easily understand it.
- Argument for a special “speech mode” of processing.
**Sine-wave speech**

<table>
<thead>
<tr>
<th>Sentence</th>
<th>SWS</th>
<th>Original</th>
</tr>
</thead>
<tbody>
<tr>
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<td>SWS</td>
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<tr>
<td>Sentence 6</td>
<td>SWS</td>
<td>Original</td>
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</tbody>
</table>
Role of articulatory gestures on speech perception

- Recognition of sine-wave speech or speech that has been degraded by noise is improved if the stimulus is accompanied by congruent articulatory gestures.
Brief article

Audio–visual speech perception is special

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Question

- Is speech perceived as all other sounds or is there a specialized mechanism responsible for coding the acoustic signal into phonetic segments?
Method, experiment 1

1. Training in non-speech mode: Subjects were first trained to distinguish between Stimulus 1 and 2, which were the sinewave replicas of the Finnish nonwords /omso/ and /onso/.

2. Non-speech test: SWS tokens were presented alone or audio-visually with a congruent or incongruent visual articulation. Subjects were instructed to indicate by a button press whether they heard stimulus “1” or “2”.

3. Natural speech test: As in 2, but now the auditory stimuli consisted of natural tokens of /onso/ and /omso/. Subjects were told to indicate whether the consonant they heard was /n/, /m/ or something else.

4. Training in speech mode: Subjects were taught to categorize the SWS stimuli as /omso/ and /onso/.

5. Test in speech mode: Indicate whether the consonant they heard was /n/, /m/ or something else.
Results

The bar chart shows the percentage of correctly identified auditory stimuli across different conditions.

- **Auditory-Only**:
  - Sinewave speech: non-speech mode: 90%
  - Sinewave speech: speech mode: 93%
  - Natural speech: 92%

- **Congruent Audio-Visual**:
  - Sinewave speech: non-speech mode: 93%
  - Sinewave speech: speech mode: 97%
  - Natural speech: 94%

- **Incongruent Audio-Visual**:
  - Sinewave speech: non-speech mode: 84%
  - Sinewave speech: speech mode: 29%
  - Natural speech: 3%
Experiment 2: Speech mode training and test occur first

1. Training in speech mode.
2. SWS in speech mode.
3. Natural speech.

Fig. 2. Experiment 2: Details as in Fig. 1.
Questions

- Is speech special?
  - Can brain damage lead to a selective loss of speech perception? YES, but no one-to-one correspondence between lesion site and type of disorder.
  - Are the mechanisms of speech perception different from the mechanisms of auditory perception in general?
    - Role of audio-visual integration may be special for speech.