Auditory Physiology

PSY 310

Greg Francis

Lecture 29

A dangerous device.

Hearing

- The sound stimulus is changes in pressure
- The simplest sounds vary in:
  - Frequency: Hertz, cycles per second. How fast the pressure changes
  - Amplitude: decibels. How big a change there is.
- Complex sounds are made up of simple sounds superimposed on each other
  - Fourier analysis / synthesis
- Obviously, we do not hear all possible sound stimuli

Auditory limits

- Different species are able to hear different frequencies of sounds

Audibility curve

- Threshold for hearing varies with frequency
- Perceived loudness also varies with frequency

Species variability

- Many animals can hear sounds at frequencies that we cannot

Speech sounds

- Speech sounds are an especially important stimulus
- They cover particular frequency ranges to which people are very sensitive
Hearing loss

- As people age, their threshold intensity for hearing tends to go up.
- Usually this is because of exposure to loud sounds.

Hearing loss

- Worse still, hearing loss tends to cover the range of frequencies that include speech.
- No one “gets used” to a noisy environment; it means you are going deaf.

Sound stimulus

- Sound waves travel down the ear canal.
- Hit the tympanic membrane (ear drum).
  - It vibrates with the sound wave.

Auditory system

- Basic anatomy of ear.

Ossicles

- The tympanic membrane is connected to a small bone.
  - Malleus
- Which connects to another bone.
  - Incus
- Which connects to another bone.
  - Stapes
- The end of the stapes.
  - Pushes against another membrane called the oval window, which is on the cochlea.

PSY 310: Sensory and Perceptual Processes
Cochlea
- Spiral shape
- Filled with fluid

Cochlea
- Several membranes that divide it into separate compartments
- The round window pushes into one of these compartments

Cochlear chambers
- A cross-section view indicates the chambers of the cochlea

Cochlear membranes
- Special cells are located on the middle membrane to respond to movement of another membrane
- These membranes move in response to pressure from the stapes on the oval window

Basilar membrane
- This membrane contains the organ of Corti

Organ of corti
- Here’s another schematic
- The whole organ stretches along the entire membrane
Organ of Corti

- Here’s a electron micrograph
  - Three rows of outer hair cells are visible

Organ of Corti

- Three main components
- Tectorial membrane
  - Sits on top
- Inner hair cells
- Outer hair cells

Organ of Corti

- When sound hits the ear and the pressure is transferred to the oval window, the basilar membrane moves
  - Show animation
- This causes the hair cells to bend
  - Show animation
- Sound energy is transduced into an electrical signal at the hair cells

Hair cells

- Each hair cell has cilia that sticks up on top of the organ of corti
- They are arranged in a particular pattern
- 16,000 to 20,000 along the whole cochlea

Inner hair cells

- This is a electron micrograph of the top of a single inner hair cell
- The cilia pivot on their base in response to movement from the tectorial membrane, which is above them

Outer hair cells

- This is a electron micrograph of the top of a single outer hair cell
- The tallest cilia are connected to the tectorial membrane, which is above them.
- The smaller cilia are connected to their larger neighbor
Hair cells

- Movement of the tectorial membrane opens a "trapdoor" on the top of the cilia
- Normally, potassium ions stay outside

Hearing loss

- Here's another view of a healthy cochlea with normal hair cells

Hearing loss

- Exposure to long-term loud noise can damage the hair cell cilia

Hearing loss

- Another comparison of a single outer hair cell
- Currently, there is no recovering from such damage
  - It is permanent hearing loss
- An iPod (or whatever) played fairly loud can lead to this kind of damage
  - If it's too loud around you to hear your music, don't listen
  - Might be a good idea to keep the earbuds in (to block sound)

Conclusions

- Anatomical structure and function of the ear
  - Outer ear
  - Middle ear
  - Inner ear
    - Cochlea
    - Basilar membrane
    - Organ of Corti
    - Hair cells
- Hearing loss
Next time

- Responses to stimulus properties
- Frequency analysis
- Place theory