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.

[Graph showing prevalence of hearing loss by age group and intensity level]

iPods

- Unfortunately, people now listen to quite loud sounds fairly often.
- And they turn up the volume in environments with loud surrounding sounds.

[Images of earphones and iPod]
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.

Auditory system

- Basic anatomy of ear

---

Prof. Greg Francis

PSY 310: Sensory and Perceptual Processes
Sound stimulus

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

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
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 an 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.

![Inner Hair Cell Stereocilia](image)

**Outer hair cells**

- This is an 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.

![Outer Hair Cell Stereocilia](image)
Hair cells

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

With pressure, the trapdoors open and potassium ions enter.

Animations

- Excitation
- Inhibition

The potassium leads to neural responses.
Hearing loss

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

- 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