Intro to Cognitive Neuroscience

Auditory perception
What is sound?

• A pattern of local increases or decreases in air pressure (usually caused by a vibrating object).

• Some terminology
  
  • Frequency
  
  • Amplitude
Ears

- Outer ear collects and amplifies sounds.
- Shape of pinna amplifies certain frequencies, in humans 2000 - 5000 Hz.
- Vibrations are transferred along the auditory canal to the eardrum.

Image courtesy of U.S. Department of Labor.
Ears

- Middle ear concentrates sound energy
- Changes in air pressure in the auditory canal cause the tympanic membrane to move.
- This in turn moves a chain of bones - the hammer, anvil, and stirrup.
- The movements of these bones are controlled by two muscles - the tensor tympani and the stapedus.

Image courtesy of the U.S. Department of Labor.
Ears

- Inner ear converts air pressure into neural signals.

- Stirrup bone presses on oval window in cochlea, creating waves in fluid within cochlea.

- Cochlea is a coil of three parallel canals.
  - Vestibular canal
  - Middle canal
  - Tympanic canal

Image courtesy of U.S. Department of Labor.
Inner ear

- Membrane between middle and tympanic canal is the **basilar membrane**; base for transduction mechanism.

- Basilar membrane is narrow near base of cochlea; wide near its apex.

- Basilar membrane moves when waves are created in surrounding fluid.

- Basilar membrane is **tuned** to frequency of waves.
Inner ear

- On the basilar membrane is the **organ of Corti** - all the stuff that converts sounds into neural activity.

- Most important are the **hair cells**.

  - One row of inner hair cells, three rows of outer hair cells.

  - Their hairs are what allow them to detect sounds.
Inner ear

- Each hair cell has both afferent (to the brain) and efferent (from the brain) nerves.

- Most auditory info comes from the inner hair cells.

- Outer hair cells can influence stiffness of basilar membrane, tuning cochlea to different sounds.
Auditory pathways

• Vestibulocochlear nerve runs from cochlea to the cochlear nuclei in the brainstem.

• Cochlear nucleus projects (mostly) to opposite superior olivary nucleus.

• Superior olivary nucleus projects to medial geniculate nucleus (in the thalamus).

• MGN projects to auditory cortex, in the temporal lobe.

• Auditory system is tonotopically organized.
Discriminating pitch

• Theory 1: Place theory - we ID pitches by the location of the hair cells that are most stimulated.

• Theory 2: Volley theory - we ID pitches by the timing of action potentials, which is related to the frequency of the sound.
Discriminating pitch

- Current theory: some of both!

- Volley coding is used for lower pitches, up to about 4000 Hz.

- Place coding is also used. Complex sounds are ID’d by a sort of Fourier analysis.