Topics

- Five important characteristics of hearing loss
  1. Degree
  2. Configuration
  3. Type
  4. Age at acquisition
  5. Speech perception

- How to record hearing loss -- The audiogram

- Pure-tone audiometric testing -- air conduction vs bone conduction

- Effect of hearing loss on speech perception

- Causes of hearing loss

- Early identification
How to describe HEARING LOSS

1. Degree of loss
   “How much”? 

2. Configuration of loss
   “Shape” – affect on each frequency range 

3. Type of loss
   Location of the problem 

4. Time at onset of loss
   Previous experience with sound 

5. Auditory speech recognition performance
1. Degree of hearing loss

Some definitions

- **“Normal”**
  - Refers to the average healthy ear
  - The comparison group for measuring hearing

- **“Decibel”**
  - A unit to measure sound intensity
  - Abbreviation is dB

- **“Threshold”**
  - The softest level you can detect about half the time
Hearing measurement scale

- Some physical events can be measured on more than one scale
  - Analogy: There are several scales for temperature--
    - 0°C Celsius = 32°F Farenheit
  - There are also several scales to measure hearing threshold

- The scale typically used to measure hearing threshold is called Hearing Level (HL)

- When we use HL, we can compare hearing ability for sounds that have very different acoustic characteristics
  - Low frequency vs. high frequency
  - Simple wave vs. complex wave
  - One word vs. another word (example: “yes” vs. “no”)
Normal-hearing threshold

- Large groups of people were tested to determine normal-hearing threshold
  - Audiologists measured the minimum intensity levels required for detection of a series of tones
  - The average minimum intensity level for each tone was called 0 dB HL ("zero decibels Hearing Level")
- Results from these studies defined a range of normal hearing
- If an individual *needs more intensity than normal* to detect a tone, we say that person has a hearing loss
Demonstration #1

- **Analogy**
  - **Light**
    - A complex combination of frequencies across a wide spectrum
    - Can be analyzed into its component frequencies
  - **Acoustic stimulus**
    - Every sound is a unique combination of frequencies and waveforms
    - Can be analyzed into its component frequencies, called pure tones

- **To test hearing, we use individual pure tones**
  - Demonstration of the audiometric frequency range
  - Demonstration of adjusting intensity level
  - The pure-tone-average threshold (PTA) is often used to summarize the level of hearing loss (using 500, 1000, & 2000 Hz)
### Categories of Hearing Loss

<table>
<thead>
<tr>
<th>Category</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>$\leq 10$ dB HL</td>
</tr>
<tr>
<td>Minimal</td>
<td>10-25 dB HL</td>
</tr>
<tr>
<td>Mild</td>
<td>25-40 dB HL</td>
</tr>
<tr>
<td>Moderate</td>
<td>40-55 dB HL</td>
</tr>
<tr>
<td>Moderately-Severe</td>
<td>55-70 dB HL</td>
</tr>
<tr>
<td>Severe</td>
<td>70-90 dB HL</td>
</tr>
<tr>
<td>Profound</td>
<td>$&gt; 90$ dB HL</td>
</tr>
</tbody>
</table>
How to record hearing loss: The Audiogram

Select the test signal frequency.

Adjust the signal level until it is “just detectable.”

Right ear: Mark “○”
Left ear: Mark “×”

Frequency of the test signal (Hz)

Intensity level of the test signal (dBHL)
Example of an audiogram showing a hearing loss

- **Hearing threshold levels**
- **Above threshold Audible**
- **Below threshold Inaudible**
2. Configuration of hearing loss

- **“Flat”**
  - All frequencies are affected about the same

- **“Low-frequency” or “Rising”**
  - Hearing loss primarily at low frequencies

- **“High-frequency” or “Sloping”**
  - Hearing loss primarily at high frequencies
Demonstration #2

- Simulations of hearing loss
  - Illustrates the effects only of sound attenuation (sound is softer)
  - Sound quality remains adequate (not distorted)
    - [http://facstaff.uww.edu/bradleys/radio/hlsimulation/](http://facstaff.uww.edu/bradleys/radio/hlsimulation/)
  a) Profound
  b) Moderate (example: “presbycusis”)
  c) Mild (example: “otitis media”)

- Why are some parts of the message more clear or less clear?
  - Some *speech sounds* depend on low-frequency hearing; others depend on high-frequency hearing
  - Some speech sounds are naturally soft; others are strong
  - Degree of hearing loss determines how many speech sounds are below threshold
The “speech banana”

- We can graph the frequency and intensity level of speech sounds in our language (examples here are for English).

- When we draw a line around these levels, the outline has a banana shape – The Speech Banana.

- The speech banana makes it easy to see how many speech sounds are audible for a person, and how many sounds the person will miss because of a hearing loss.
For a person with normal hearing, all of the sounds of speech, and most environmental sounds, are audible.
For a person with hearing loss, some speech sounds and environmental sounds are **inaudible**.
3. Type of hearing loss

- Indicates location of the problem
  - Conductive mechanism
    - Outer ear
    - Middle ear
  - Sensorineural mechanism
    - Sensory cells in the cochlea
    - Neural system (in the cochlea or along the 8th nerve)
Air Conduction “AC”
Tests the whole system

Bone Conduction “BC”
Tests sensorineural system only

Conductive mechanism
Sensorineural mechanism

Conductive hearing loss
Only AC results show loss

Audiogram for a Conductive Hearing Loss

Conductive

- A problem of loudness
- Maximum level of conductive loss is about 55 dB
- Structural or medical problems are effectively treated with medicine or surgery
- Hearing aids provide a high degree of benefit
Sensorineural hearing loss

AC and BC results show equal loss

Audiogram for a Sensorineural hearing loss

Sensorineural

- A problem of loudness and distortion
- Hearing aids are effective in restoring loudness
- Hearing aids cannot improve sound perception
- Hearing aid technology can improve the acoustic signal
- Listening experience and language knowledge facilitate auditory speech perception
Mixed hearing loss
BC better than AC

Audiogram for a Mixed Hearing Loss

Other hearing loss variables

Unilateral ----------- Bilateral
Symmetrical --------- Asymmetrical
Sudden --------------- Progressive
Fluctuating ----------- Stable
4. Age at onset of hearing loss

- **After auditory speech and language have developed**
  - Acquired
  - Adventitious
  - Postlingual

- **During early auditory speech and language development**
  - Perilingual

- **Before auditory speech and language development**
  - Prelingual
  - Congenital
Listening and spoken language depend on early access to sound

- Degree of hearing loss is not a reliable predictor of outcome
  - Profoundly deaf individuals can be successful communicators with spoken language (listening and speaking)

- Ease of acquisition increases with early identification and early intervention (with a hearing aid or cochlear implant)

- Degree of hearing loss becomes a much stronger predictor of outcome when there is delayed identification or intervention
5. Speech recognition performance

- Conditions are selected according to the objectives of the test
  - With earphones or best-fit hearing aids
  - In quiet or in noise
  - Live voice or recorded voice
  - Speech or environmental sounds

- Speech recognition tests use a variety of stimuli
  - Speech sounds in syllables (examples: “aba”, “ada”, “aga”)
  - One-syllable words (examples: “tie”, “pig”, “cat”)
  - Two-syllable words (examples: “mailbox”, “ice cream”)
  - Sentences
5. Speech recognition performance

- Speech recognition tests use a variety of responses
  - Recognition ("Say the word _____.")
  - Closed-set identification (Choose from these words: "Mailbox, baseball, ice cream, sunset")
  - Discrimination ("same" or "different")

- Often measured in percent correct

- **Performance cannot be predicted from audiogram alone**
How to describe HEARING LOSS

1. Degree of loss
   “How much”?

2. Configuration of loss
   “Shape” – affect on each frequency range

3. Type of loss
   Location of the problem

4. Time at onset of loss
   Previous experience with sound

5. Auditory speech recognition performance
Causes of hearing loss in children

- **Genetic factors** in congenital hearing loss
  - Cause of about half of all congenital hearing loss
  - Autosomal dominant -- one parent (deaf) carries the dominant gene for hearing loss and passes it along to the child
  - Autosomal recessive -- both parents (hearing) carry a recessive gene for hearing loss
  - X-linked hearing loss -- mother carries the recessive trait for hearing loss on the sex chromosome and passes it on to males, but not to females
  - Genetic syndromes that include hearing loss
    - Down
    - Neurofibromatosis (NF)
    - Waardenburg
    - Treacher-Collins
    - Crouzon
    - Alport
    - Pendred

http://www.babyhearing.org/HearingAmplification/Causes/genetics.asp
Nonhereditary causes of congenital hearing loss in children

- Prenatal or perinatal infections, illnesses, toxins consumed by the mother
  - Usually sensorineural
  - Can be mild to profound
  - Examples
    - Rubella, cytomegalovirus (CMV), herpes simplex virus
    - Rh complications
    - Prematurity
    - Maternal diabetes
    - Toxemia during pregnancy
    - Anoxia (lack of oxygen)
Acquired causes of hearing loss in children

- Noise exposure

- Ototoxic drugs

- Head injury (eardrum perforation; temporal bone fracture)

- Radiation treatment
Acquired causes of hearing loss in children

- Meningitis
- Measles
- Encephalitis
- Chicken pox
- Mumps
- Impacted cerumen
- Developmental defects (microtia, atresia)

http://www.microtia.us.com/
Otitis Media (OM)

- Inflammation of the middle ear, often with fluid, which may or may not be infected.

- Severity, duration, and frequency of inflammation vary between children. If child does not show pain or fever, OM may go unnoticed and untreated.

http://www.entusa.com/eardum_and_middle_ear.htm
Otitis Media (OM)

- Symptoms can include:
  - Severe pain, fever
  - Tugging at the ears
  - Hearing loss
    - Mild or moderate conductive hearing loss, particularly in the low frequencies
    - Conductive loss can add to an existing sensorineural hearing loss
    - Repeated bouts can result in glue-like fluid and permanent hearing loss
  - Difficulty understanding speech
  - Inattentiveness
  - Language and speech delay
  - Fatigue

- Chronic OM may be treated with ear tubes to aid pressure equalization and drainage

Central Auditory Processing Disorder (CAPD)

- Disruption in transmission of sound from the brain stem to the cerebrum
- Information received by the temporal cortex may be incorrect or may be processed incorrectly
- Signs include difficulty with these skills:
  - Understanding speech that is degraded, fast, or spoken with an accent
  - Listening in noise
  - Associating meaning to sound
  - Memory for sound sequences
  - Localizing and lateralizing sound
  - Discriminating sounds
  - Recognizing sound patterns
  - Following the rhythm and melody of music
Early identification

- Universal newborn hearing screening
  - Otoacoustic emissions test (OAEs)
    - Measures internally generated sound from the cochlea in response to a stimulus
    - Depends on healthy external and middle ear
    - Child must be asleep
  - Auditory Brain Stem Response test (ABR)
    - Measures brain’s response to sound
    - Uses scalp electrodes
    - Child must be quiet

- Expected referral rate in U.S. < 4%
  - 2-10% of babies do not pass the screen
  - Less than 1% will have a hearing loss

- Concerns
  - Parents may not follow up
  - Family may be worried unnecessarily, especially if there is a false positive
Early identification

- Tests for older infants and children
  - Behavioral observation audiometry (BOA) for young infants
  - Visual reinforcement audiometry (VRA) for children from 6 mos to 2-1/2 years of age
  - Conditioned play audiometry (CPA) for children aged about 2-1/2 years or older

www.hearingtune.com/images/vra.jpg