The anatomy and physiology of the ear

- Three components
  - Outer ear
  - Middle ear
  - Inner ear
  - 8th cranial nerve
Types of hearing loss

- **Conductive**
  - Caused by outer and middle ear problems
  - Often can be corrected by surgery or medication

- **Sensorineural**
  - Caused by diseases involving the inner ear or the central auditory system.
  - Not treatable

- **Mixed**
  - Contain both the conductive and sensory components.

- **Functional (nonorganic)**
Degree of hearing loss

Mild: 26-40 dB (children: 15-40 dB)
Moderate: 41-55 dB
Moderately severe: 56-70 dB
Severe: 71-90 dB
Profound >91 dB

PTA (pure tone average): 0.5, 1 and 2 kHz
Time course of hearing loss

- **Progressive**
  - Eg. Aging related hearing loss, autoimmune disorders

- **Sudden**
  - trauma
  - idiopathic sudden deafness

- **Fluctuating**
  - Meniere’s disease
Effects of hearing loss on understanding language and speech

- **Minimal or borderline hearing losses (16-25 dB HL)**
  - These children may appear inappropriate, awkward, or immature.

- **Mild losses (26-40 dB HL)**
  - These children seem as if they are “day dreaming” or not “paying attention”
• **Moderate loss (41-55 dB HL)**
  - Missing 50-100 % of the speech signal.
  - Likely to have limited vocabulary, delayed or defective syntax, imperfect speech production, and an atonal voice quality

• **Moderately severe to profound loss (>56 dB HL)**
  - Missing 100% of the speech signal

• **Unilateral hearing losses**
  - Having difficulties hearing faint or distant speech.
  - Having difficulties hearing in noisy environments
  - Difficulty localizing sound source
Evaluation of the auditory system

- Tympanometry
- Pure tone testing
- Speech testing
- Auditory brainstem response test
- Otoacoustic emission test
- Assessment for auditory processing
• **Decibel (dB)**
  ○ A logarithmic unit for the measurement of the level of sounds.

• **Sound pressure level (SPL):**
  ○ Reference level: 20 µPa

• **Hearing level (HL)**
  ○ Reference level: hearing thresholds of normal listeners

• **Sensation level (SL)**
  ○ Reference level: the presentation level above threshold
# Audiogram Code

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Audiogram – Degree of HL

- Normal
- Mild
- Moderate
- Moderately severe
- Severe
- Profound

26-40 dB HL
56-70 dB HL
>91 dB HL
41-55 dB HL
71-90 dB HL
Impact of hearing loss

www.ahaanet.com/images/OtiKidsAudiogramSounds.gif
Audiogram: types of HL

Sensorineural  Conductive  Mixed
Audiogram Configurations

Flat, sloping and precipitous

Reverse-slop or low frequency

Notch
Audiogram Lateralization

Unilateral

Asymmetric
Audiogram—others
Audiogram

- Lateralization
- Degree
  - Mild, moderate, moderately severe, severe and profound
- Configuration
  - Flat, sloping, precipitous, notch
- Type
  - Based on air conduction vs. bone conduction
  - conductive/sensorineural/mixed (air-bone gap)
- Eg. Bilateral – mild to moderately severe - sloping - SNHL
Speech testing (1)

- **Speech-awareness threshold (SAT)**
  - Also known as speech-detection threshold (SDT).
  - The lowest level at which speech can be detected at least half the time.
The speech-reception threshold (SRT)
- The lowest level at which speech can be identified at least half the time.
Word Recognition (discrimination) testing

- To estimate the ability to understand and repeat single-syllable words presented at conversational or another suprathreshold level.
- Important audiometric predictor of hearing aid benefit.
Auditory brainstem response (ABR) testing

- Recording an action potential that is conducted along the eighth nerve and the brainstem.
- ABR testing is reliable, objective and noninvasive
- Clinical applications:
  - Evaluate the function of the eighth nerve and the brainstem
  - Obtain objective threshold (difficult-to-test patients)
Otoacoustic emission testing (OAE)

- Evaluating the OHC functions
- Two types of OAE used in clinic
  - Transient otoacoustic emissions (TOAEs):
  - Distortion product otoacoustic emissions (DPOAEs)
- Clinical applications
  - Difficult-to-test patients
  - Assesses outer hair cell integrity
  - Used in the testing battery for the diagnosis of auditory neuropathy
Hearing tests for Children

- Neonatal screening
  - ABR and OAE

- From 7 months to 2 yrs
  - Visual reinforcement audiometry (VRA)
    - 1, 2, and 4 kHz at 30 dB HL for screening
  - Play audiometry
    - 1, 2, and 4 kHz at 20 dB for screening

- 3-5 yrs
  - Conditioned play audiometry
  - Conventional audiometry
  - For screening: 1, 2, and 4 kHz at 20 dB HL
Hearing tests for Children

- 5-18 yrs
  - **When:**
    - Initial entry to school
    - Entrance to special education
    - Grade repetition
    - Annually in kindergarten through 3\textsuperscript{rd} grade and in 7\textsuperscript{th} and 11\textsuperscript{th} grades
  - Conventional audiometry or conditioned play audiometry
  - For screening: 1, 2 and 4 kHz at 20 dB
Auditory Processing Assessment

- **Buffalo Model**
  - Decoding
  - Tolerance Fading-Memory
  - Integration
  - Organization

- What we do with what we hear!
(C)APD Assessment

Purpose:
1. delineate disordered auditory processes,
2. evaluate the impact on educational, medical and social aspects,
3. develop appropriate management strategies.
Other types of childhood disorders may exhibit similar behaviors, e.g., attention deficit hyperactivity disorder (ADHD), language impairment, reading disability, autistic spectrum disorders.

Some audiological test battery may fail to distinguish CAPD from children with other problems.

Other confounding factors, e.g., lack of motivation, attention, cooperation and understanding.
Neuromaturational Effects

- Auditory discrimination for speech sounds is present at birth-improves until approximately age 8
- Temporal resolution improves until about age 8
- Right ear advantage reaches adult values around age 12-13
- MLD reaches adult values at about 6 years
- Attention, memory, problem solving, linguistic and cognitive skills develop through puberty and beyond
Multidisciplinary Assessment

- Ideal but not always possible
- Obtain comprehensive background information and previous test reports including:
  - Neuropsychological reports
  - Speech-language reports
  - Teacher/educational reports
  - Medical/imaging reports
  - Previous audiological reports
  - Social worker reports
  - Parent report
Test Battery Approach

- AP is a complex, multifunction system
- No one test assesses every level and function
- Determining an auditory deficit is not enough, function must be assessed as well
- Site of lesion and peripheral assessment must be included
Auditory Processing Tests

- Behavioral vs. objective
- Behavioral procedures assess the individual’s responses to what they perceive.
- Monotic: low redundancy, temporal tasks, speech in noise
- Dichotic: binaural integration (SSW) vs. binaural separation (CST)
- Binaural
The battery includes:

- Case history/Buffalo Model Questionnaire
- Complete auditory peripheral assessment
- Speech in Noise test
- SSW test
- Phonemic Synthesis test
- Temporal processing tests (if possible)
The Buffalo Model

• **Case history information**
  - Comprehensive background information including health, development, educational, academic, and family history
  - Reports from previous evaluations
  - Teacher(s) input: SIFTER, CHAPS
  - Buffalo Model Questionnaire
Other related signs:
- Auditory processing
- Psychological
- Learning disability
- Behavior
- Ear infections/ fluid
- Coordination
- Hypersensitivity to touch
- Head injury
- Allergies
- Math
- Eye contact with speaker
- Memory long-term
- Mentally challenged
Peripheral Assessment

- Otoscopy
- Tympanometry
- Acoustic reflex thresholds-ipsi and contra
- Pure tone audiometry
- Word discrimination score using recorded speech materials
Speech in Noise Tests

- **UB S/N test:**
  - CID W-22 Word Lists 1 & 2 A
  - Multi-talker noise at a +10 dB S/N
  - Presented in three conditions: R, L, and binaural
  - Difference Scores for each, compare to age norms
Speech in Noise Tests

- **Other tests:**
  - Katz CD speech in noise test
  - BKB test
  - SCAN Auditory Figure Ground subtest
  - HINT test
  - Listening in Spatialized Noise – Sentences Test (LiSN-S)
    - New!
    - Developed by Harvey Dillon, et al.
    - National Acoustics Laboratory (NAL), Sydney, Australia
Dichotic Listening

- Kimura (1961): contralateral pathways are stronger & more numerous than ipsilateral
- During dichotic listening, the ipsilateral pathways are suppressed by contralateral pathways
- Right ear advantage (REA) is usually apparent in dichotic listening. Why?
SSW Test

- 40 staggered dichotic test items
- Presented at 50 dB SL
- Scoring includes number of quantitative errors and qualitative responses
SSW Test
SSW Test
Quantitative Scoring

- SSW norms
  - Norms from over thousand cases
  - Age norms age 5-59
Qualitative Scoring:

- Delays & quick responses
- Reversals
- Ear effect/Order effect
- Type A pattern
- Repeating & responding to the carrier phrase
- Tongue twisters
- “Smushes”
- Back-to-back responses
- Perseverations
The Central Test Battery

- www.precisionacoustics.org

- Includes:
  - Ira Hirsh’s W-22 Word List 1D & 2D
  - Ira Hirsh’s W-22 Word List 3D & 4D (With Speech Spectrum Noise for a Speech-In-Noise Task)
  - Staggered Spondaic Word Test – List EC
  - Phonemic Synthesis Test
  - Phonemic Synthesis Picture Test
  - Competing Environmental Sounds Test – List E2
  - Phoneme Recognition Test