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Pure-tone Testing and Audiogram Interpretation

Audiology Online: Back-to-Basics Series
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Disclosures

Relevant Financial Relationships
- Honorarium for moderating Back to Basics Series
- Honorarium for presenting
- Royalties from sale of textbook entitled
  - Pure-Tone Audiometry and Masking (Plural)
  - Several audiograms used with permission

Relevant Non-Financial Relationships - None

Introduction and Rationale

- Pure-tone testing serves as a foundation for many other comprehensive assessment techniques
- The audiologist often views pure-tone testing as a first step in assessment of new patients
- Obtaining and interpretation of a valid audiogram is extremely important and perhaps not as simple as it originally seems

Outline

I. Introduction
II. Preparing for Testing
III. Equipment Considerations and Set-up
IV. The Audiogram and Audiometric Symbols
V. Sample Instructions
VI. Pure-tone Testing Procedures
VII. Obtaining Valid Results
VIII. Audiogram Interpretation
IX. Explaining Results

Hearing Science Foundation

- Knowledge of Acoustics is crucial
  - Simple Harmonic Motion
  - Complex Waveforms
  - Parameters of Sound
    - Frequency
    - Intensity
    - Time Domain

(Haughton, 2002; Emanuel, 2013)

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Hearing Science Foundation

- Knowledge of Anatomy of the Ear is crucial
  - Outer Ear
  - Middle Ear
  - Inner Ear
  - Central Auditory Nervous System

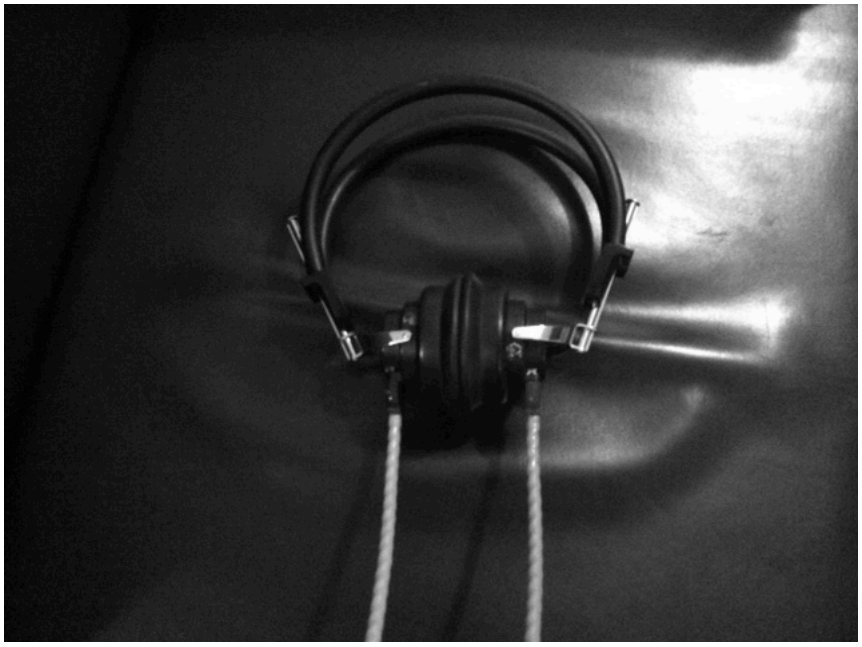
(Clark & Ohlemiller, 2007; Emanuel, 2013)

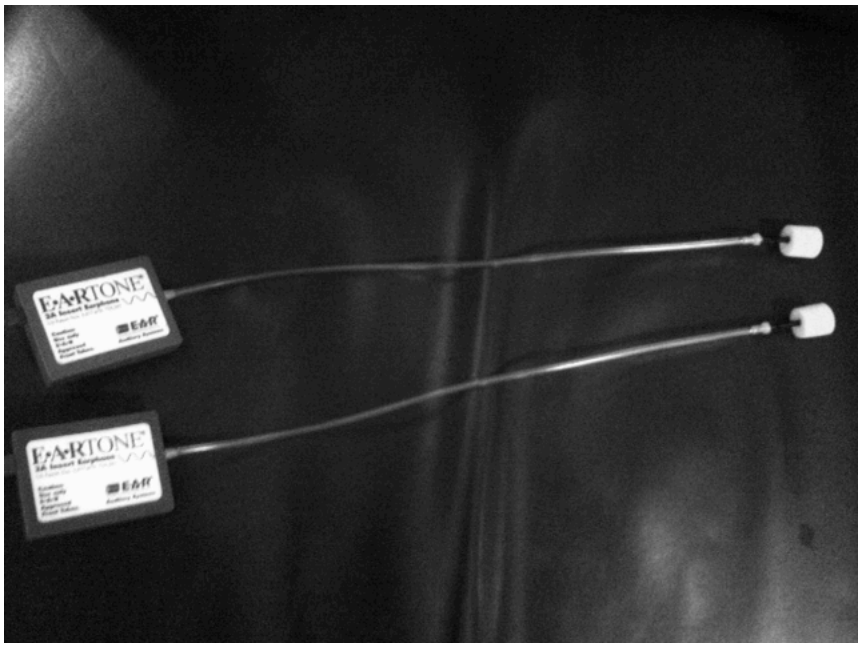
Preparing for Testing

- Calibration and Daily Listening Checks
- Equipment Considerations
- The Sound Suite
- The Audiometer
- Transducers for Air Conduction (AC) and Bone Conduction (BC) Testing
- A Word about Sound Field Testing

(ANSI, 2004; Roeser, 2013)


GSI

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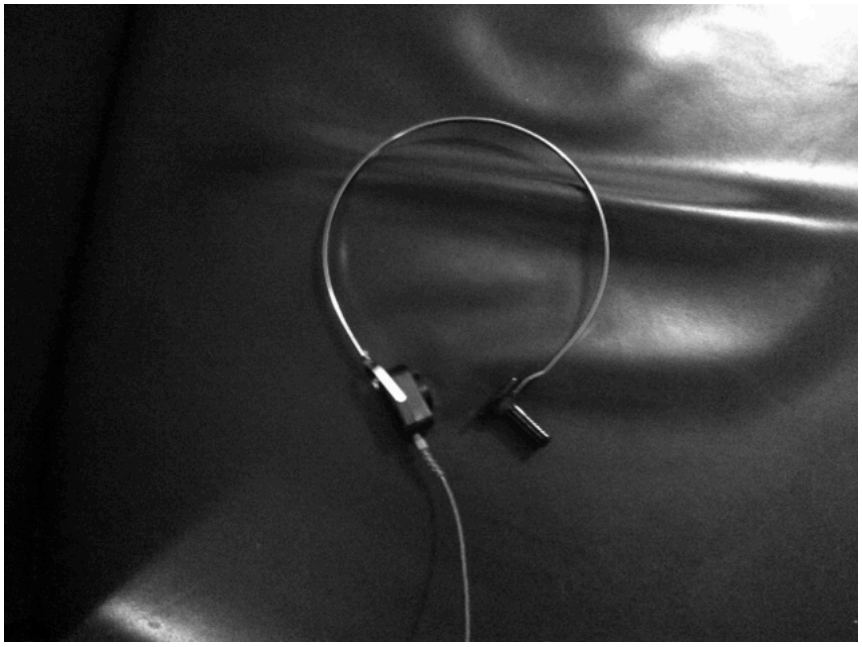

Preparing for Testing

- Taking a thorough Case History
- Otoscopic Examination
  - Checking for cerumen
  - Checking for collapsed canals
  - Viewing the tympanic membrane
  - Checking for visible disorders

Equipment Set-up

- Delivery of tonal stimuli in monaural fashion
- Select proper transducer (AC first)
- Select ear (often starting with better ear)
- Selection of frequency (often starting with 1 kHz
- Initial starting point in dB HL
- Continuous off – examiner delivers stimulus

Final Preparations and Terminology

- Instructions to patient
- Seating of patient
- Talk-back system in place
- Proper placement of transducer
- Descending vs. Ascending Methods
- Definition of Threshold
- These are behavioral/conventional techniques
- These are samples and guidelines – audiologists utilize varying procedures

Sample Instructions

I am going to place some earphones on your ears. You will hear some tones. Some of them will be very soft. Please raise your hand every time you hear one, even if very soft. Do you have any questions?

Modified Hughson-Westlake Procedure

- Start at 1 kHz in better ear
- Start w/ right ear if one is not better
- Present tone for approximately 2-3 seconds
- Down 10 dB with each + response
- Up 5 dB with each – response
- Record softest level heard at least 50% of the time

(Carhart & Jerger, 1959; ANSI, 2004; ASHA, 2005)

Modified Hughson-Westlake Procedure

- Test 2k, 4k, 8k, 500 and 250 Hz
- Switch to the other ear
- Be sure to instruct patient throughout
- Test BC with same procedure, other than at 8 kHz
- Neatness and uniformity of symbols
- Connect AC thresholds
- Do not connect BC thresholds

When do we test mid-octaves?

- Test mid-octave frequencies when the difference between the two adjacent octave frequencies is 20 dB or more
- Be sure to include these frequencies when you are connecting your symbols
- Mid-octaves: 750, 1500, 3k, 6 kHz

Audiometric Symbols

- Right ear traditionally recorded in red
- Left ear traditionally recorded in blue
- Air conduction unmasked thresholds:
- red O for right
- blue x for left
- Air conduction masked thresholds:
- red triangle for right
- blue square for left

(ASHA, 1990)

Audiometric Symbols

- Bone conduction unmasked thresholds
- < in red for right
- > in blue for left
- Masked thresholds: [in red for right
-] in blue for left
- Arrow indicates NR at equipment limits
- S indicates sound field threshold
- Proper placement of symbols is important
- Symbols may be in black and white and/or computer-generated

What is Clinical Masking?

- Audiology Online held a lecture last year on Clinical Masking
- Process of presenting narrow band noise to non-test ear during pure-tone testing of test ear
- This is to prevent the non-test ear from participating
- The audiologist learns rules for when to mask, appropriate intensity levels of noise, and the proper procedure

Variables Affecting Results

- Tester/audiologist variables
- Equipment variables
- Signal variables
- Patient variables

The Pure-tone Average: 3 Frequency

- Many audiologists find by averaging AC thresholds at 500, 1k and 2 kHz
- Add these numbers and divide by 3
- Round off to nearest whole dB
- Example: 35 dB at 500, 45 dB at 1k and 50 dB at 2k: PTA = 43 dB HL
- Find this value for each ear
- This should relate to the softest level at which the patient will receive speech

The Pure-tone Average: 2 Frequency

- Some audiologists may calculate if:
- The difference between two consecutive frequencies (500 and1k and/or 1k and 2k) is 20 dB or more
- If this is the case, they may average the two better frequencies
- E.g. 500 = 35 dB, 1k = 55 dB, 2k = 60 dB
- Omit the 2k threshold and average 500 and 1k
- PTA = 45 dB HL
- With specific audiometric configurations, this calculation may provide a better estimate of the intensity level at which a patient receives speech

Interpretation Parameters

Magnitude: Is there a loss? If so, how severe?

Type: Conductive, sensorineural or mixed?

Configuration: Audiometric shape

Symmetry: comparison of right and left ears

Some Commonly-Used Guidelines for Determining Magnitude of Hearing Loss

- 0-15 dB Within normal limits
- 16-25 dB Slight
- 26-40 dB Mild
- 41-55 dB Moderate
- 56-70 dB Moderately severe
- 71-90 Severe
- 90+ Profound
- Interpret AC across the frequency range per ear

Type of Hearing Loss

- Think about AC versus BC testing and anatomical structures involved.
- Ask 3 questions:
- Loss by air (AC)?
- Loss by bone (BC)?
- Significant air-bone gap (ABG)?
- Significant ABG: AC threshold is greater than 10 dB poorer than BC threshold at that frequency

Type of Hearing Loss

	AC loss?	BC loss?	Sig ABG?
■ Cond	yes	no	yes
■ SN	yes	yes	no
■ Mixed	yes	yes	yes

Examples of Audiograms

See previous audiogram that displays:

Hearing sensitivity within normal limits in left ear

A mild to moderate conductive hearing loss in the right ear

Examples of sensorineural and mixed hearing losses of varying magnitudes will follow

Symmetry

- This may not be as precise and may be "eyeballed" by the clinician
- For the purposes of our discussion, we will define as:
- The audiogram is symmetrical between ears when the difference between AC thresholds is no more than 10 dB at all test frequencies. Audiologists also look at BC thresholds to help determine symmetry – or at least expected symmetry in the event of ABGs being present and alleviated following medical management

Configuration: Shape of the Audiogram

- The following categories may also be helpful to the audiologist:
- Flat: <5 dB rise/fall per octave
- Grad Falling: 5-12 dB decrease per octave
- Sharply Falling: 13 dB or more decrease per octave
- Abruptly Falling: flat or grad falling, then sharply falling

(Stach, 1998)

Configuration

- Rising: 5 dB or more increase per octave
- Trough: 20 dB or greater loss at 1K and/or 2K than at 500 and 4K
- Miscellaneous: Does not fit any of the above
- Look at AC thresholds, primarily at 500 – 4K
- Audiologists also look at the BC "line" to help determine configuration, especially when significant ABGs are present

Explaining Results: Some Suggestions

- This is a graph that we make of the hearing. Across the top are the pitches of the tones you heard, from low to high pitch.
- Down the side is the loudness, from very soft to very loud. The o's represent the softest level at which you heard with the earphones for your right ear and the x's represent the softest heard for your left.

Explaining Results

- If your hearing were plotted within this range, it would be within normal limits. We classify hearing loss into categories or ranges from slight to profound. Your hearing for the right ear is (describe magnitude) and for the left ear is (describe magnitude).
- We then put the little oscillator behind your ear to present more tones. This helps us determine where the hearing loss lies.

Explaining Results

- A basic anatomical drawing is helpful here. Our testing indicates that your hearing loss is a result of some type of problem within your (OE/ME or IE) system. You may wish to draw their attention here to AC/BC relationships and explain briefly.
- You will then explain symmetry.
- Finally, you will explain the configuration: that the client hears better at some frequencies (if rising or falling) or that he basically hears all frequencies similarly (if flat).

Explaining Results: Final Note

- You will add your explanation of Speech Audiometry including these and any others (see previous AO presentation):
  - Speech Recognition Threshold (SRT) and
  - Word Recognition Scores (WRS)
- The SRT (in dB HL) should be in good agreement with the PTA (in dB HL) for each ear
- WRS will be in % correct out of 100%
- Immittance: Tympanometry and Acoustic Reflex Threshold Testing
- These tests help assess the auditory system and validate your previous results, including type of hearing loss
- Explanation of additional test findings and recommendations
- Answering of questions and Counseling, Counseling, Counseling

Upcoming Presentations

Audiology Online Back-to-Basics Series

A previous presentation was also held on the topic of Speech Audiometry.

October 30th: Immittance Audiometry
Lisa Hunter, Ph.D.

November 6th: Pediatric Audiology
Christine Yoshinaga-Itano, Ph.D.

Thank you so much!

What questions do you have?

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