ADULT PURE-TONE AUDIOMETRY

Pure-Tone Audiometry – Adults

**Purpose:** The main role of adult diagnostic audiometry is the measurement of frequency specific hearing thresholds.

**Test Preparation**

1. Obtain correct forms & prepare test area

2. Perform listening checks on equipment including level (pure tones & masking noise) and distortion checks; calibrate speech tape and/or CD using VU meter

3. Check referral and plan appropriate assessment procedures

**Otoscopy** (should do this *prior* to pure tone audiometry in adults)

1. Check that ear canals are clear

2. Check for collapsing canals

**Instructions to Client**

(ANSI S3.21-1978)

1. Indicate test purpose

2. Indicate the need to respond even when sound is very faint (i.e., encourage guessing)

3. Indicate that ears will be tested separately

4. If audiometer is outside booth, tell client you can hear them speaking via microphone

5. Require a clear behavioural response (button push, hand raise, tap, etc)

**Transducer Placement**

1. Earphone diaphragm should be opposite ear canal opening on both sides

2. May have to remove glasses (*but* only do this if glasses are obstructing headphone placement - it is better to leave glasses on if possible if the client has a hearing loss and is partially reliant on lip reading for communication), push back hair

3. Check comfort (e.g., due to headphone cushions pushing against earrings etc

4. Remember that the client may not be able to hear you when earphones are in place
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5. When placing bone vibrator ensure that it is on mastoid, not touching pinna, and not uncomfortable.

6. If using insert earphones be sure that foam plug is inserted so that the outer edge of the insert phone is at least flush with the opening of the ear canal. **If the insert phone is poorly inserted, (i.e. the insertion depth is shallow), then the usual rules regarding interaural attenuation for insert phones DO NOT apply. Under these conditions, the insert phones are more likened to that of supra-aural phones with respect to inter-aural attenuation values and the likelihood of the occlusion effect occurring with low frequency stimuli.**

7. Remember to always perform otoscopy before using insert earphones, and to repeat otoscopy if the client experiences any discomfort due to insertion of the insert plug.

8. Be sure that you have threshold correction factors if using insert earphones with an audiometer that does not have separate outputs for supra aural and insert earphones (note that insert correction factors are negative in the high frequencies).

**Test Method**

[modified Hughson-Westlake ascending method (Carhart & Jerger, 1959)]

1. Generally test better ear first (if known)

2. Starting level 30 or 50 dB HL, depending on whether hearing loss is suspected. Since you normally would suspect a hearing loss generally begin at ≥ 50 dB HL.

3. Once you have determined the first threshold start presentation at next frequency at a level 15-20 dB higher (unless the levels are very high and loudness recruitment might be a problem)

4. Go up in steps of 15-20 dB until initial response obtained (preparation phase)

5. Decrease level 10 dB if response occurs, increase in 5 dB steps if no response

6. Threshold = lowest HL at which responses occur on at least one-half of ascending trials, with a minimum of two responses out of three presentations at that level

7. Frequency order = 1000, 2000, 4000, 8000, retest 1000 (reliability check), 500, 250 Hz

8. Tone duration should be 1-2 seconds, with ≥ 3 seconds between presentations

9. Test between-octave frequencies (750, 1500, 3000, and/or 6000 Hz) if AC thresholds drop ≥ 20 dB between octave frequencies (or if the person complains of hearing problems but the audiogram appears normal)
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10. Always test 1.5, 3 kHz and 6 kHz if noise-induced loss suspected or if a more detailed audiogram is required (e.g., client complains of hearing difficulties and audiogram seems normal).

11. Remember to correct hearing thresholds using appropriate correction factors when using insert earphones before plotting on audiogram.

12. Air conduction threshold symbols should only be connected together once you have established whether or not masking is required. When there was no response at the limits of the audiometer the symbol should not be connected to other hearing threshold symbols as it does not indicate a true threshold.

13. If there is no response at lower presentation levels test up to the limits of the audiometer (this will vary across frequency and across transducer).

14. At high intensity levels air conduction responses can be vibrotactile, especially in the low frequencies. If the person indicates that they are feeling rather than hearing the tone this should be indicated on the audiogram by writing VT (vibrotactile) beside the threshold.

Recommended scale for classification of degree of hearing loss:

Table 2

<table>
<thead>
<tr>
<th>Average Hearing Threshold Level in dB (re: 1969 ANSI)</th>
<th>Hearing Loss Label</th>
</tr>
</thead>
<tbody>
<tr>
<td>-10-15</td>
<td>Normal Hearing</td>
</tr>
<tr>
<td>16-25</td>
<td>Slight Hearing Loss</td>
</tr>
<tr>
<td>26-40</td>
<td>Mild Hearing Loss</td>
</tr>
<tr>
<td>41-55</td>
<td>Moderate Hearing Loss</td>
</tr>
<tr>
<td>56-70</td>
<td>Moderately Severe Hearing Loss</td>
</tr>
<tr>
<td>71-90</td>
<td>Severe Hearing Loss</td>
</tr>
<tr>
<td>91+</td>
<td>Profound Hearing Loss</td>
</tr>
</tbody>
</table>


Bone Conduction

1. Frequency order = 1000, 2000, 4000, 500 Hz (and then 250 Hz if tested)
2. It is common clinical practice to test BC at octave frequencies from 500 to 4000 Hz if a hearing loss is obtained on air conduction testing. On occasion it may be useful to test at other frequencies (e.g. 250 Hz)

3. The starting level for BC audiometry should be ~ 20 dB above the better AC threshold (if there is a large asymmetry BC tones will be heard initially in non-test ear so start presentation about 20 dB above AC threshold in non-test ear)

4. When testing low frequencies (usually 500, 250 Hz) at high levels check whether person "hears" or "feels" tone. Vibrotactile (VT) responses should be noted on the audiogram by writing "VT" on the audiogram.

5. If there is the possibility that bone conduction thresholds are vibrotactile and the correct diagnosis depends on whether bone conduction thresholds are auditory or vibrotactile then this should be investigated using the technique described by Dean & Martin (1997). Place the bone conductor on the forehead instead of the mastoid. If hearing thresholds (dB dial) improve, then the thresholds are probably vibrotactile since the forehead is more sensitive to vibrotactile stimulation. If hearing thresholds (dB dial) are worse at the forehead, then the thresholds are probably auditory since the forehead is less sensitive to bone conducted auditory stimulation.

6. Acoustic radiation may give artificially improved bone conduction thresholds in the high frequencies. If bone conduction testing for at 4000 Hz results in an unexpected negative air bone gap, then an ear plug should be placed in the ipsilateral (test) ear and the bone conduction threshold rechecked.

MASKING IN PURE-TONE AUDIOMETRY

When To Mask
INTER-AURAL ATTENUATION

<table>
<thead>
<tr>
<th>Frequency Hz</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1000</th>
<th>2000</th>
<th>4000</th>
<th>8000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supra-aural</td>
<td>35</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>45</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Insert*</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
</tbody>
</table>

*Correct insertion depth – outer edge of foam flush with tragus.

See Katz & Lezynski, Katz 5th ed p127 for supra-aural phones p140 for insert phones

Mask bone conduction if air-bone gap in test ear is \( \geq 15 \) dB and AC threshold exceeds normal limits \( \geq 15 \) dB HL

Notes:

You can mask AC immediately after doing AC in both ears if difference between AC thresholds for test and non-test ears equals or exceeds the IAA value for that transducer. You may however have to do additional AC masking after BC testing is completed.

Plateau Method
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1. Introduce masking at AC threshold of non-test ear (correct level if using insert earphones to mask; note that insert corrections are subtracted from the pure tone threshold values on the audiogram to get insert masking dial levels).

2. Increase masking in 10-dB steps and (if required for tone to be audible) increase test tone in 5-dB steps until at least a 20 - 30 dB plateau is obtained (2 - 3 steps of 10 dB). Generally a 20 dB plateau is adequate but you may wish to be more conservative and obtain a 30 dB plateau if results appear unreliable or inconsistent. (Generally a 30 dB plateau is recommended at 250, 500 and 1000 Hz, if possible, due to the occlusion effect – see point 3 below.) Remember however that overmasking is more likely to occur if you are seeking a longer plateau.

3. The occlusion effect should be taken into account when testing low frequency bone conduction thresholds using supra-aural phones. It should not occur with correctly inserted insert phones.
   The occlusion effect is an improvement in low frequency bone conduction thresholds that occurs when the non test ear is occluded. Usually the improvement occurs in the non-test ear because this ear is occluded by an earphone in order to provide masking. The occlusion effect is typically 20-30 dB at 250 Hz, 15-20 at 500 Hz, 5-10 dB at 1000 Hz and negligible at higher frequencies for supra-aural earphones (Yacullo 1996). Where necessary, additional masking should be introduced (e.g., require at least a 30 dB plateau) to ensure that accurate masked test ear bone conduction thresholds are obtained.

4. If you introduce masking to the non-test ear and the test ear threshold changes by only 5 dB with increases in masking level in the non-test ear it is a good idea to confirm that this 5 dB increase is not simply test-retest error. You can test for this by reducing the level of the tone in the test ear by 5 dB and re-presenting to confirm that the threshold really has reliably moved by 5 dB with the introduction of masking.

5. Note that you may need to accept a shorter plateau and/or use a smaller (5 dB) step size to increase masking if there is a masking dilemma and note this on the audiogram. Insert earphones can also be used to reduce the chance of a masking dilemma occurring since they provide about an additional 10 - 20 dB IAA.

6. A short plateau (i.e. < 20 dB) should only be accepted when there is a risk of overmasking (i.e., when the level of masking in the non-test ear exceeds the tone presentation level in the test ear by 40 dB or more for supra-aural earphones and 50/60 dB or more for insert earphones, depending on the frequency being tested).

7. If you are unable to mask and obtain a plateau because the hearing loss is asymmetrical and you are near the limits of the audiometer this should be indicated on the audiogram (e.g. by writing “insufficient masking available”, or “overmasking?, unable to find plateau”, etc).

Step Masking

* Alternative to plateau method
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- More rapid because masking is increased in larger steps

Air Conduction

Initial Masking

- Mask if: HLTE ≥ Min IA + BCNTE

1. Introduce masking at a level 30 dB higher than air conduction threshold in non-test ear.
   
   *eg with a threshold of 10 dB HL in non-test ear, masking is introduced at 40 dB HL into the non-test ear*

2. Recheck threshold. If no change, accept current signal level as correct threshold or repeat response if you are concerned about reliability

3. If there is a change, increase signal level until response obtained.
   - If there is a change of 15 dB or less, accept this is correct threshold (small amount of cross hearing)
   - If threshold shifts by 20 dB or more, further masking is required. (see subsequent masking below)

Subsequent Masking

1. Increase masking level by another 20 dB
   
   *e.g. in above example, “initial masking” was 40 dB HL. In “subsequent masking” this increases to 60 dBHL.*

2. Recheck threshold: if no change, or change of less than 15 dB, accept this is correct threshold.

3. If there is a change of 15dB or more, another round of “subsequent masking” is required. (see 2nd round of subsequent masking below)

2nd Round of Subsequent Masking

1. Increase masking level another 20dB.

2. When no significant threshold increase with “subsequent masking” or there is no response at audiometer limit, then we
have the proper information.

Bone Conduction

Assume IAA = 0 dB at all frequencies

Initial Masking
  • Mask if: TE ABG ≥ 15 dB

  1. Introduce masking at a level 20 dB higher than AC NTE threshold.

  Note: If using supra-aural phones additional masking will be needed for the occlusion effect: 15 dB at 250 Hz and 500 Hz and 10 dB at 1000 Hz

  Correctly positioned insert phones do not create an occlusion effect (see point 6 regarding correct insertion depth of insert phones)

  2. If threshold shifts by 15 dB or more then subsequent masking is required

Subsequent masking

  1. Increase masking level another 20 dB.
  2. When no significant threshold increase with “subsequent masking” or there is no response at audiometer limit, then we have the proper information.
  3. If there is a change of 15 dB or more, another round of “subsequent masking” is required (see below)

2nd Round of Subsequent Masking

  1. Increase masking level another 20 dB.
  2. When no significant threshold increase with “2nd round of subsequent masking” or there is no response at audiometer limit, then we have the proper information.
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Note: Correction for the OE is only required for Initial Masking