Clinical Masking for Audiometric Testing in Adults

PURPOSE

The Valente (2006) guidelines "Auditory Assessment and Diagnosis" (part 2.1) indicate that the objective of the auditory assessment is to diagnose the type and magnitude of hearing loss and the need for treatment, including candidacy for amplification.

SCOPE

All registered audiologists and/or registered hearing instrument practitioners

BACKGROUND

In order to properly assess the type and magnitude of hearing loss, proper masking techniques may be required. Martin, Armstrong and Champlin (1994) as well as Martin, Champlin and Chambers (1998) suggested that many audiologists (and likely by extension HIPS) "use improper determinations for the need to mask and/or fail to mask using a logical method" (p. 18). The 1998 study suggested that many hearing health care providers continue to use inappropriate masking procedures

It is generally accepted that masking is effective at the establishment of true air and bone conduction thresholds. It is also widely recognized that when one identifies the possibility of under masking or over masking, that the procedure be discontinued as a result.

The most common masking procedure is the plateau method (first described by Hood, 1960). In a survey by Martin (1994), 58% of survey respondents use some variant of this technique. The plateau method is well established in the research literature. The original plateau method by Hood (1960) recommended establishing unmasked thresholds. If required, apply masking to the NTE and re-establish the threshold was recommended. The masking level should be increased in 10 dB steps until the measured threshold "remains constant with further additional incremental steps of 10 dB" (Hood, 1960, p. 1227).

Yacullo (1996) recommended the masking level be "increased over a range of at least 15 to 20 dB" (p. 73), while Roeser and Clark (2000) recommended 5 dB steps.

Turner (2004) defined the plateau method as: measure unmasked air conduction (AC) for each ear and an unmasked bone conduction threshold.

At each frequency, determine if masking is required using conventional criteria.

Set the initial masking level (IM) 10 dB above the AC threshold of the non-test ear (NTE) and re-establish threshold. The masking level is increased 10 dB and the threshold re-established.

When the making level is increased twice (20 dB range) with no change (poorer) in threshold, the masker is in the plateau, and the measured threshold is the actual threshold.

It is also well established that there is no one universally correct protocol or procedure for masking.

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DEFINITIONS

I**nter-aural attenuation** (IA): the reduction in intensity of sound presented to the one ear before it reaches the other ear

Masking: defined as the process by which the threshold of hearing for one sound is raised by the presence of another(masking) sound (American National Standards Institute [ANSI] as cited in Yacullo, 2000).

Minimum masking level: "the minimum level of noise that is needed in the non-test ear to eliminate its response to the test signal" Yacullo (2000, p. 97).

Maximum masking level: "the maximum level of noise that can be used in the non-test ear that can be used that will not change the true threshold or response in the test ear" Yacullo (2000, p. 98).

Occlusion effect: In clinical testing, when masking for bone conduction, the occlusion effect is created inadvertently when placing an earphone over or inserted into the non-test ear" Vento & Durrant, 2009, p. 55). During vocalization, bone-conducted energy results in vibration of the mandible and soft tissue located in close proximity to the external canal. This in turn causes vibration of the canal's cartilaginous walls, producing energy that is subsequently transferred to the volume of air within the canal. When the ear canal is occluded, much of this energy is trapped, causing an increase in the sound pressure level delivered to the tympanic membrane and, ultimately, to the cochlea (MacKenzie, 2006).

Overmasking: occurs when "even with contralateral masking, the true threshold or response in the test ear has been changed" Yacullo (2000, p. 99).

Threshold: the minimum hearing level for detection of pure tone or speech stimuli at which an individual can just discern the presence of the stimuli 50% of the time (American Speech-Language-Hearing Association, 2014).

Undermasking: occurs when, even with contralateral masking, the test signal continues to be perceived in the nontest ear (Yacullo, 2000, p. 93-95)

Vibrotactile threshold: for mastoid location of the bone vibrator, vibrotactile threshold may be as low as 25 dB at 250 Hz, 55 dB at 500 Hz, and 70 dB at 1000 Hz (Boothroyd & Cawkwell, 1970), although large variations may occur. Care must be taken not to misinterpret vibrotactile perceptions as hearing (British Society of Audiology, 2004).

APPLICATION PARAMETERS

When criteria are identified that point to the need for masking, masking must be used for both air conduction and bone conduction thresholds. Yacullo (2000) noted that "based on currently available data, a conservative estimate of IA for supra-threshold earphones is 40 dB at all frequencies" (p. 81); "Based on currently available data, conservative estimates of IA for 3A insert earphones with deeply inserted foam ear tips are 75 dB at <_ 1,000 Hz and 50 dB at frequencies > 1,000 Hz" (p. 83); and "based on currently available data, a conservative estimate of IA for bone-conducted sound is 0 dB at all frequencies" (p. 85).

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Masking Rule Information

NOTE: All information in these subheadings is from Yacullo (2000).

AC Test Ear – BC Nontest Ear ≥ IA

Contralateral masking is required during pure tone air-conduction audiometry when the unmasked air-conduction threshold in the test ear equals or exceeds the apparent bone-conduction threshold (i.e., the unmasked bone-conduction threshold) in the nontest ear by a conservative estimate of IA. (Yacullo, 2000, p. 85)

AC Test Ear – AC Nontest Ear ≥ IA

Contralateral masking is required during pure tone air-conduction audiometry when the unmasked air-conduction threshold in the test ear (AC test ear) equals or exceeds the air-conduction threshold in the nontest ear (AC Nontest ear) by a conservative estimate of IA. (Yacullo, 2000, p. 87)

Air-Bone GapTest Ear ≥ 15 dB Where Air-Bone Gap = ACTest Ear – Unmasked BC

The use of contralateral masking is indicated whenever the results of unmasked bone-conduction audiometry suggest the presence of an air-bone gap in the test ear (Air-Bone Gap Test Ear) of 15 dB or greater. (Yacullo, 2000, p. 87)

Presentation LevelTest Ear – Best BC Nontest Ear ≥ IA

Contralateral masking is indicated during speech audiometry whenever the presentation level of the speech signal (in dB HL) in the test ear (Presentation Level test ear) equals or exceeds the best pure tone bone-conduction threshold in the nontest ear (Best BC Nontest Ear) by a conservative estimate of IA. (Yacullo, 2000, p. 88)

STTest Ear – STNontest Ear ≥ IA

Contralateral masking is required during measurement of threshold when the speech threshold in the test ear (STTest Ear) equals or exceeds the speech threshold in the nontest ear (STNontest Ear) by a conservative estimate of IA. (Yacullo, 2000, p. 89)

When measuring the bone-conduction thresholds of lower frequencies, the occlusion effect must be taken into account. Research has shown a number of different correction-factor values used to account for the occlusion effect when using supra-aural/circum-aural headphones such as:

		250 Hz	500 Hz 1000 Hz
Goldstein & Newman (1994)	15 dB	15 dB	10 dB
Yacullo (1996)	30 dB	20 dB	10 dB
Roeser & Clark (2000)	20 dB	15 dB	5 dB

The values for *properly placed* insert earphones are significantly smaller. Yacullo (1996) recommended 10 dB at 250 Hz and no other correction factors.

NOTE: Any threshold considered to be vibrotactile should be noted on the audiogram.

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ASSESSMENT AND/OR DIAGNOSIS OF CONDITION OR DISORDER

Masking Procedures Using Inserts and Standard Headphones

Research has consistently shown that the plateau method is superior to other methods. It has not been able to show that one protocol is superior to another. The College of Speech and Hearing Health Professionals of British Columbia (CSHHPBC) advocates the use of the plateau method of masking for air and bone conduction as outlined here:

1. Select initial amount of masking for the non-test ear (i.e., air-conducted threshold of the non-test ear ($AC\theta_{Nontest}$ + 10 dB HL), plus correction factor for occlusion effect, if applicable.
2. Re-establish threshold in the test ear with this initial amount of masking (e.g., $AC\theta_{Nontest\ Ear}$ + 10)
3. Each time there is a response to the pure-tone signal presented to the Test Ear, increase the masking presented to the Non-Test ear by 5 dB.
4. Each time there is no response to the tone presented to the Test Ear, increase the signal presented to the Test Ear by 5 dB steps until another response is observed.
5. Continue this procedure until a plateau is observed – that is, when three consecutive 5-dB increases in masking are given without an observed shift in the response (threshold) of the Test Ear.
6. Record the masked threshold and the final level of masking used on the audiogram.

Research has consistently shown that the plateau method is superior to other methods. It has not been able to show that one protocol is superior to another.

See charts in Appendices A, B, and C that summarize masking protocols, all based on the plateau method of masking, that are currently (2014) taught in the following programs:

- Grant MacEwan University – Hearing Aid Practitioner Program
- I.I.H.I.S. Hearing Instrument Studies Distance Education Program
- U.B.C. Master's program in Audiology.

DOCUMENTATION

Starting and stopping points for masking used should be noted on the audiogram. Both unmasked and masked thresholds should be shown on the audiogram.

Documentation must be in compliance with the CSHHPBC standard of practice PRCS-P-01 Documentation and Record Management and clinical practice guideline CPG-04 Documentation and Record Management.

CLINICAL OUTCOMES

The clinical outcome is to correctly assess hearing loss magnitude and type.

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RELATED CSHHPBC DOCUMENTS

Adult Ear Related Red Flags: Medical Referral Criteria (PROT-QA-01)

Clinical Masking for Audiometric Testing in Adults

Audiological Management of Adult Hearing Impairment (Valente, 2006) (CPG (A)-06)

Documentation and Record Management (CPG -04)

Hearing Assessment and Hearing Instrument Fitting and Dispensing for Adults (POLICY-QA-05)

Documentation and Record Management (SOP-PRAC-01)

Real Ear Probe Microphone Measurement Verification of Hearing Aids in Adults (PROT-QA-02)

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APPENDIX A: GRANT MACEWAN UNIVERSITY – HEARING INSTRUMENT DISPENSING PROGRAM

Masking Protocol

TE=Test Ear NTE=Nontest Ear ABG=Air Bone Gap PL=Presentation Level OE=Occlusion Effect

Test	When to Mask	Initial Noise Level	Process
Air Conduction Pure tones	$AC_{(TE)} - BC_{(NTE)} \geq 40$	$AC_{(NTE)}$ + 10 dB	Plateau Method Increase the noise by 5 dB for each response and increase the signal by 5 dB for each nonresponse, until the signal remains constant for a 15 dB increase in noise.
Bone Conduction Pure tones	$ABG_{(TE)} \geq 15$	$AC_{(NTE)}$ + 10 dB +OE* *Headphones 30 dB at 250 Hz 20 dB at 500 Hz 10 dB at 1000 Hz	
SRT	$SRT_{(TE)}$ – best $BC_{(NTE)} \geq 40$	$SRT_{(NTE)}$ + 10 dB	
Word Recognition	$PL_{(TE)}$ – best $BC_{(NTE)} \geq 40$	$PL_{(TE)}$ - 20 dB or $PL_{(TE)}$ - 30 dB if can't tolerate PL - 20	Turn on the noise at the initial intensity level. Complete the test with the noise constant at the initial masking level.

Inter-aural Attenuation

Air Conduction Avg. = 40 dB (headphones)

Hz	125	250	500	1K	2K	4K	8K
IA	35	40	40	40	40	50	50

Bone Conduction = 0 to 10 dB

APPENDIX B: I.I.H.I.S. – HEARING INSTRUMENT STUDIES DISTANCE EDUCATION PROGRAM

Masking Protocol TE=Test Ear NTE=Nontest Ear ABG=Air Bone Gap PL=Presentation Level OE=Occlusion Effect			
Test	When to Mask	Initial Noise Level	Process
Air Conduction Pure tones	$AC_{(TE)}$ – 40 dB IA ≥ $AC_{(NTE)}$ Or $AC_{(TE)}$ – $BC_{(NTE)}$ ≥ 40	$AC_{(NTE)}$ + 10 dB	Plateau Method Increase the noise by 5 dB for each response and increase the signal by 5 dB for each nonresponse, until the signal remains constant for a 15 to 20 dB increase in noise. Check for overmasking: $EM_{(NTE)}$ ≥ $AC_{(TE)}$ + 40 dB _____ Turn on the noise at the initial intensity level. Complete the test with the noise constant at the initial masking level.
Bone Conduction Pure tones	$ABG_{(TE)}$ ≥ 15	$AC_{(NTE)}$ + 10 dB +OE* * Headphones 15 dB at 250 Hz 15 dB at 500 Hz 10 dB at 1000 Hz	
SRT	$PL_{(TE)}$ ≥ 40 of $PTA_{(NTE)}$ or $SRT_{(NTE)}$	$PL_{(TE)}$ - 20 dB	
Word Recognition	Always	$PL_{(TE)}$ - 20 dB	Turn on the noise at the initial intensity level. Complete the test with the noise constant at the initial masking level.

Type of Masking Noise recommended:

Broad band for masking speech audiometry

Narrow band noise for masking pure tones

Interaural Attenuation

Air Conduction Avg. = 40 dB (headphones) 70 dB (inserts)

Hz	125	250	500	1K	2K	4K	8K
IA	40	40	50	55	60	65	70

Bone Conduction = 0 dB

Speech = 40 to 50 d

APPENDIX C: U.B.C. MASTER'S PROGRAM IN AUDIOLOGY AUDI 552 – DIAGNOSTIC AUDIOLOGY, "CLINICAL MASKING: HOW AND WHEN TO MASK," COURSE LECTURE NOTES, JANUARY – APRIL 2010; INSTRUCTORS, SUSAN SMALL, NAVID SHAHNAZ

Masking Protocol

TE=Test Ear NTE=Nontest Ear ABG=Air Bone Gap PL=Presentation Level OE=Occlusion Effect EM=Effective Masking

Test	When to Mask	Initial Noise Level	Process
Air Conduction Pure tones	$AC_{(TE)}$ - IA ≥ $AC_{(NTE)}$ or $AC_{(TE)}$ – IA ≥ $BC_{(NTE)}$	$AC_{(NTE)}$ + 15 dB (minimum = $AC_{(NTE)}$ then add 15 to be safe)	Plateau Method Start initial masking level. If $AC_{(TE)}$ stays the same or changes by 5 dB, accept AC TH and record as masked. If $AC_{(TE)}$ changes by 10 dB or more, increase noise by 5 dB Repeat until $AC_{(TE)}$ stays the same while masking increased by 5 dB in 3 consecutive steps. Check final masking level for over masking: $EM_{(NTE)}$ –IA < $BC_{(TE)}$_
Bone Conduction Pure tones	$ABG_{(TE)}$ > 10	$AC_{(NTE)}$ + 15 dB +OE* *Headphones 20 dB at 250 Hz 15 dB at 500 Hz 5 dB at 1000 Hz Inserts 10dB at 250 Hz	
SRT	AC(TE) - IA > BC (NTE)	$PL_{(TE)}$-35 dB + avg $ABG_{(NTE\ at\ .5,1K,2K\ Hz)}$	
Word Recognition	AC(TE) - IA > BC (NTE)	$PL_{(TE)}$-25 dB + avg $ABG_{(NTE\ at\ .5,1K,2K\ Hz)}$	

Interaural Attenuation

Air Conduction – Headphones

Hz	125	250	500	1K	2K	4K	8K
IA	35	40	40	40	45	50	50

Air Conduction - Inserts

Hz	250	500	1K	2K	3K	4K	6K
IA	75	85	75	65	65	60	65

Bone Conduction = 0 dB

Speech = 45 dB