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Masking: Pure and Simple
Audiology Online
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Outline

I. Introduction
II. Definitions and Theory of Masking
III. Why is Masking Important?
IV. Types and Amounts of Noise Used
V. Rules for When to Mask
VI. Equipment and Set-up
VII. Pure-tone and Speech Procedures
VIII. Recording of Results
IX. Examples

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 patients
- Obtaining and interpretation of a valid audiogram is extremely important and perhaps not as simple as it originally seems
- Masking plays a significant role
Definitions

- **Masking**: Interference in perception of one stimulus caused by presence of another
- There are many examples in our daily listening environments
- **Effective Masking**: Ability of a noise to mask signal of known frequency and intensity
- Must understand theory and principles of Hearing Science before implementing Clinical Masking

What is Clinical Masking?

- Audiology Online hosted a lecture several years ago 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
**Clinical Scenario: To Set the Stage**

Patient with Right Unilateral Hearing Loss

Test Left Ear first (AC) and find hearing within normal limits

As we test Right Ear, we see responses due to crossover:

- Occurs by AC – sound travels around the head
- Occurs by BC – sound travels through the head to non-test ear, the Left Ear in this case

We need to place masking noise in that ear, so that it does not participate in testing
What Happens When Proper Masking is Not Implemented?

- Impacts validity of test results
- There could be an adverse perception of the audiologist’s skills
- Can underestimate magnitude of hearing loss
- Can inappropriately identify type of hearing loss
- Can lead to inappropriate recommendations and treatment strategies
- Risk of litigation
- Consider ALL aspects of audiology diagnostics where masking is necessary
Additional Definitions

- Interaural Attenuation (IA)
- Shadow Curve
- Test Ear (TE)
- Non-Test Ear (NTE)
- Undermasking: Too little noise
- Overmasking: Too much noise
- Effective Masking: Just right!

Hearing Science Foundation

- Knowledge of masking concepts is crucial
- Most effective masker of a tone is a narrow band of noise that is centered about that tonal frequency
- Therefore, it is optimal that narrow bands of noise are used during masking of pure tones
- We will also discuss intensity aspects of the noise and how much noise will be effective
- With regard to the time domain, signal and noise will be presented simultaneously

(Haughton, 2002; Berlin, 2013)
Interaural Attenuation (IA) - AC

- Based upon three variables:
  - Subject variability
  - Frequency spectrum
  - Earphone transducer type

- Traditional need for masking is based upon minimal IA level of 40 dB
- IA may approach 60-65 dB
- Benefits of insert earphones: 70 - 100 dB

Ranges of IA in dB
(TDH-39 Earphones)

- 250 Hz  500 Hz  1 kHz  2 kHz  4 kHz  8 kHz
- 44-80   45-80   40-80   45-75   45-85   45-80

Most use TDH-49/50 earphones with ranges being the same.

Interaural Attenuation (IA) - BC

- Both cochleas stimulated at the same time when stimulus presented
- Minimum IA – traditionally felt to be 0 dB
- Could be slightly higher dB level in some cases
- Revisitation of occlusion effect (OE): low frequency BC sound transmission increases with ear occlusion; BC thresholds may improve
- Average OE values: 21 dB, 18 dB and 7 dB (250, 500 and 1 kHz); most test in 5 dB steps
- Some clinicians obtain a patient’s individual values

(Roeser & Clark, 2007)

Occlusion Effect (OE) Example

- Obtain and record unmasked BC threshold – no occlusion of NTE with earphone
- Example: 10 dB HL
- Configure patient for masking with earphone placed on NTE.
- Re-establish BC threshold – no noise presented yet
- Example: 0 dB HL
- OE = 10 dB
What Type of Noise?

- White noise considered efficient by some
- Narrow bands of noise (NBN) for pure-tone testing are preferred
- Consider spectra of pure-tone and the narrow band: use of NBN requires less energy to mask signal
- Speech noise for speech audiometry - shaped to correspond to speech frequencies (300 - 3k Hz)
- Reminder: Regular calibration must also take into account noise stimuli
Preparing for Testing

- Calibration and daily listening checks
- Equipment considerations
  - Sound suite
  - The audiometer
  - Transducers for air conduction (AC) and bone conduction (BC) testing
- Listening check of transducers for noise delivery

(ANSI, 2004; Roeser, 2013)

When Should We Mask?

- Because of conservative rules, we may implement masking when unnecessary, taking into account minimum IA levels
- Rule for AC: When AC threshold of TE exceeds BC threshold of NTE by 40 dB or more at that frequency
- Use best clinical insight to determine when to mask, if all thresholds have not yet been obtained
- Keep this rule in mind for other forms of AC testing, such as speech audiometry
- Some clinicians may use a different rule for inserts, in view of greater IA levels
- Rule for BC: When BC threshold of TE is more than 10 dB better than AC threshold of TE at that particular frequency (significant air-bone gap)
Masking Rules: Important Point

- Rule for AC masking is *contralateral* comparison between AC of Test Ear and BC of Non-Test Ear

- Rule for BC masking is *ipsilateral* comparison between AC of Test Ear and BC of Test Ear

How Much Noise?

- Threshold can shift in the TE as a result of various masking levels in NTE

- See diagram of *plateau* with:
  - Masking noise level along x axis in dB HL
  - Level of pure-tone stimulus in dB HL along y axis
  - Response to pure-tone stimulus – dotted line

- Undermasking (A-B), minimum permissible (B),
  maximum permissible (C) and overmasking (C-D)

- Effective masking: B-C
Undermasking

- Test signal presented to TE but perceived by NTE due to insufficient level of noise in NTE
- Audiologists could have misjudged potential IA
- True thresholds not obtained because the TE signal is still being perceived by the NTE
Plateau
- Threshold remains stable when masking noise in NTE is increased over plateau range
- Example: if range of noise is 25 dB (from 35 to 60 dB), then below 35 dB would be undermasking and above 60 dB would be overmasking
- Plateau width will vary from patient to patient; need to record noise levels on audiogram
- Factors that may affect: AC thresholds in NTE, IA variability, transducer type, OE magnitude
- Many strive for a plateau of 15 dB during clinical masking

Overmasking
- Plateau may occasionally not be found
- If this occurs, repeat the masking process and report that it was repeated
- You may only be able to accept a 10 dB plateau; use experience and clinical insight to record most valid result
- Overmasking: excessive masking noise crosses over from the NTE to the TE and interferes with perception of the signal
- Masking Dilemma – to be discussed later
Final Preparations and Terminology

- Instructions to patient
- Seating of patient
- Talk-back system in place
- Proper placement of transducers
- Descending vs. ascending methods
- These are behavioral/conventional techniques
- Many children will adapt to tasks for masking
- These are samples and guidelines – audiologists utilize varying procedures

Sample Instructions

- “You will hear a static-like noise in the opposite ear. Please try to ignore it and listen for the tone. Raise your hand every time you hear the tone, regardless of where you think you are hearing it. Raise your hand even if it is very soft.”
- Modify as necessary for speech audiometry, for example asking patients to repeat the word(s).
Minimum Effective Noise Levels

- For AC (in NTE):
  - AC threshold of NTE + 10 dB + ABG of NTE

- For BC (in NTE):
  - AC threshold of NTE + 10 dB + OE

- Formulae vary and there is no one correct way
- For example, some may not consider ABG or OE

- Different formulae may result in audiologists’ starting with varying levels of noise

Let’s revisit this diagram, this time as related to how much noise to deliver to NTE when starting the masking procedure. Different formulae result in clinicians’ starting levels to vary on AB segment, but to finish on BC segment with proper attaining of threshold.
Equipment Configuration

- Two channel audiometer is necessary
- Ch 1 still configured for pure-tone testing (TE); transducer is either AC or BC
- Starting intensity (tonal stimulus) is unmasked threshold
- Ch 2 configured for noise delivered to NTE
- Transducer is AC (phone or insert)
- The noise is continuously on
- Starting intensity (noise) is derived from previously-described formulae

The Procedure

- Instructions
- Re-establish unmasked threshold
- Present noise at calculated intensity level
- Present tone at same level in noise; you will avoid the Hughson-Westlake procedure here
- With + response, raise noise (5 dB)
- With – response, raise tone (5 dB)
- Most audiologists try to find plateau and valid threshold in 5 dB steps
When Do You Stop?

- You will likely go through a process of raising the tone by 5 dB and raising the noise by 5 dB.
- Then you will reach plateau, where patient will maintain hearing of the tone at constant hearing level over:
  - + 5 dB increase of noise
  - + 5 dB increase of noise
  - + 5 dB increase of noise
  - Many audiologists will strive for a 15 dB plateau.

When Do You Stop?

In other words, there will be a 15 dB increase in the level of the noise presented to the NTE with no required change in the level of the signal to the TE.

Sometimes, you plateau immediately without a need to raise the tone in 5 dB increments.
Three Possible Outcomes

- AC: Masked threshold could = unmasked threshold
  - Threshold could diminish to limits of equipment
  - Threshold could be somewhere “in between” these first two scenarios

- BC: Masked threshold could = unmasked threshold
  - BC threshold could diminish to meet AC threshold (or BC equipment limit)
  - Threshold could be somewhere “in between” these first two scenarios

How to Record Thresholds

- For AC and BC: record only your masked thresholds on your audiogram
- Unmasked are not valid and are not necessary to record
- Record noise levels over which tone was maintained at threshold: minimum and maximum noise value of your plateau
- Example: record masked symbol on audiogram at threshold; record that this was maintained over plateau of noise (such as 35-50 dB)
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
- You may see this symbol for unmasked BC: ^
- Masked thresholds: [ in red for right
  - ] in blue for left
- Arrow attached to symbol 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
Masking Dilemma

- Bilateral conductive hearing loss where you may be concerned about undermasking and overmasking at the same time
- Many reduce need for masking by using inserts for AC testing
- Can help verify conductive loss with immittance
- Practice! Practice! Practice!
Important Points – Masking Dilemma

- On previous audiogram, unmasked BC for both ears will reflect what is recorded here
- Reflection of better ear
- Unmasked BC (both) can help initially with learning and then we use critical thinking to visualize
- We must mask all thresholds here in that rules are met for AC and BC

Masking Dilemma

- Which are true thresholds? We do not know until we mask
- Example: AC threshold for R ear at 1 kHz
- Noise in NTE (LE): 50 dB HL (AC threshold) + 10 = 60 dB HL and could already be perceived by BC in NTE
- If we add ABG, which is challenging until we know what the BC threshold is, that is 50 dB!
- We will be at the limits of equipment and there is risk of crossing over; we may have too little and too much noise at the same time
- Multiply this dilemma times all frequencies; a similar scenario is noted for BC
When Should We Mask for Speech?

- For SRT: when presentation level in TE exceeds best BC threshold (NTE) by 40 dB or more (500 - 2k Hz)

- For WRS: when presentation level in TE exceeds the best BC threshold in any of the speech frequencies (NTE) by 40 dB or more

- Amount of noise calculated in similar fashion: must consider IA, whether a suprathreshold measure, and fluctuation of speech stimulus

Illustrative Cases and Key Points

Masking needed for RE AC at 1 kHz and 2 kHz
Also for RE BC at .75 kHz, 1 kHz, 2 kHz and 4 kHz
No masking is needed for AC in either ear or for BC thresholds of RE. However, we need to mask BC at all frequencies but 4 kHz.

Final Pearls

- Insights and experience will tell you when signal may be crossing over
- Remember that rule for AC masking compares AC of TE to BC (not AC) of NTE
- There may be instances of 40 dB difference between AC thresholds; you can feel pretty comfortable of BC threshold value
- Consider scenario where AC difference is only 20 dB; masking may not be performed (and should be) if apply incorrect rule of comparing AC thresholds
- ABG could exist in that NTE.
Final Pearls

- Use AC threshold of NTE as a base when determining masking noise level
- Be able to rationalize what you are doing and why
- Consider aspects of OE: not demonstrated with CHL or in higher frequencies
- Use solid theory as a base when anticipating when to mask – for example, when you don’t have all thresholds yet or when you automatically configure each patient for possible masking
- Correct recording of symbols and noise levels

Thank you so much!

What questions do you have?
References


References (continued)


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