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The ABCs of Masking: A Foundational Guide for Audiology Students and Clinicians

O. Ogundiran[1*], A. Azaglo[1], D. N. A. Lamptey[1], M. K. Gomashie[1], A. K. Aboagye[1],
D. Addy[1], S. Adaklutse[1], V. N. Owusu[1], E. A. Apppiagyei[1]
[1]Department of Speech Language and Hearing Sciences, University of Heath and Allied Sciences, Ho, Ghana
[*]Corresponding Author: Dr. Olawale Ogundiran
Address: Department of Speech, Language and Hearing Sciences, University of Heath and Allied Sciences, Ho, Ghana
Email: oogundiran@uhas.edu.gh

Abstract
Clinical masking is a foundational procedure in audiology that ensures accurate auditory threshold measurements by preventing the non-test ear from participating in the test process. This paper comprehensively explores the principles, procedures, and implications of clinical masking within audiology. With a focus on both air and bone conduction testing, the document delves into the necessity of masking, interaural attenuation, central masking, over-masking, and effective masking levels. Furthermore, the text discusses clinical scenarios, masking dilemmas, recent advancements, and educational strategies for enhancing audiologists' competencies. Emphasis is placed on evidence-based practices, incorporating contemporary research findings, and offering recommendations for early carrier audiologist competency.

Key words: masking, non-test ear, test ear, interaural attenuation
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Introduction

Masking is an essential technique in audiology used to isolate the auditory response of one ear by preventing crossover hearing to the non-test ear (NTE). This process ensures the accuracy of audiometric evaluations, particularly in cases of asymmetric hearing loss or conductive pathologies. Without masking, sound presented to the test ear (TE) may be detected by the NTE, especially at higher intensities, thus yielding unreliable thresholds (Perkins & Mitchell, 2025).

Clinical masking safeguards the integrity of diagnostic outcomes, forming a critical aspect of best practice protocols. This aims to ensure that the test ear hears the presented tone and is not cross heard by the non-test ear. Cross-hearing occurs when a tone presented to the test ear overcomes interaural attenuation (IA), which refers to the loss of acoustic energy as sound waves travel transcranially to the contralateral ear (Perkins & Mitchell, 2025).

The concept hinges on interaural attenuation, the reduction in sound energy as it travels across the skull. IA varies depending on the transducer used: for supra-aural headphones, the average IA is approximately 40 dB (Katz & Lezynski, 2002), whereas insert earphones can provide IA values exceeding 55 dB (Smith & Markides, 1981). In bone conduction (BC) testing, where IA can be as low as 0 dB, masking is almost always necessary. Thus, understanding IA is central to determining when and how masking should be applied (Hood, 1960).

Moreover, masking procedures are critical in ensuring diagnostic precision across varied populations, including pediatrics and geriatrics. Children and older adults may present with conditions that necessitate more meticulous masking strategies due to anatomical or neurological variations. Incorporating standardized masking protocols in routine hearing assessments mitigates the risk of misdiagnosis and ensures equitable auditory care (Hood, 1960).

Historical Perspective

The concept of masking in audiology dates to the early 20th century, evolving alongside the development of audiometric techniques. Early audiologists recognized the need to control for cross-hearing, especially in bone conduction testing. The work of Raymond Carhart and Lloyd Hood in the 1950s was instrumental in shaping modern masking protocols, particularly the plateau method, which remains a cornerstone of clinical practice (Hood, 1960).

The 1970s and 1980s saw the formalization of masking strategies, with organizations like the American Speech-Language-Hearing Association (ASHA, 2005) and the American National Standards Institute (ASHA, 2005)

publishing masking guidelines. These standards contributed to the consistency and accuracy of audiological assessments across clinical settings.
The advent of digital audiometry and automated testing in recent decades has further refined masking techniques. These innovations, coupled with a growing emphasis on evidence-based practice, have underscored the importance of accurate masking in diagnosing hearing disorders and planning appropriate interventions (Martin & Clark, 2019).

Principles of Clinical Masking
The fundamental principle of clinical masking lies in the concept of interaural attenuation (IA), which refers to the loss of energy as a sound travels from the test ear to the non-test ear. The amount of IA varies depending on the type of transducer used: approximately 40 dB for supra-aural headphones, 55 dB for insert earphones, and 0 dB for bone conduction (Smith & Markides, 1981).

Crossover hearing occurs when the test signal presented to one ear is heard by the opposite ear, potentially compromising the accuracy of threshold measurements. Masking is employed to prevent this by introducing noise to the non-test ear, ensuring that the response is solely from the test ear. The masking dilemma arises when the level of masking noise required to prevent crossover itself crosses over to the test ear, leading to a situation where accurate thresholds cannot be established (Seneviratne et al., 2019).

Clinical masking is especially critical in cases of unilateral or asymmetrical hearing loss, where accurate differentiation between sensorineural and conductive components is necessary for diagnosis and treatment planning.

Indications for Masking
Three rules of masking indicate when masking should be employed, as explained by Studebaker in 1964.
Rule 1
This rule applies when there is a difference in non-masked air conduction between each ear, equal to or greater than 40dB (55dB if using inserted earphones).
Rule 2
When there is a difference between the non-masked bone conduction threshold and the air conduction threshold of either ear is greater than 10dB.
Rule 3
When rule 1 has not been applied and where the bone conduction threshold of one ear is better by 40dB (or 55dB if using insert earphones) than the air conduction threshold of the contralateral ear.

Masking Strategies
Initial Masking Level (IML)
The IML is the minimum level of masking noise introduced into the non-test ear. It's calculated to just prevent cross-hearing at the outset.
Formula:
For air conduction masking:
IML = AC(NTE) + 10 dB safety factor
For bone conduction masking:
IML = BC(TE) + (ABG in NTE) + 10 dB
Where:
AC(NTE): Air conduction threshold of the non-test ear
BC(TE): Bone conduction threshold of the test ear
ABG: Air-bone gap in the non-test ear (if present)
The 10 dB safety factor ensures that the masking is above the hearing threshold of the NTE.
Maximum Masking Level (MML)
The MML is the highest level of masking noise that can be applied to the NTE without causing over masking i.e., where the masking noise crosses over and affects the TE (Martin & Clark, 2014)
Formula:
MML = BC(TE) + IA - 5 dB
Where:
BC(TE): Bone conduction threshold of the test ear
IA: Interaural attenuation (e.g., 40 dB for headphones, 55 dB for insert earphones)
The 5 dB buffer accounts for variability and prevents over masking.

Masking Procedure

Plateau Method

The Plateau Method is the gold standard for confirming that the masking level in the non-test ear (NTE) is sufficient to eliminate its contribution without affecting the threshold of the test ear (TE).

Steps of the Plateau Method:

Step 1: Determine the IML (Initial Masking Level).

Step 2: Present the test tone to the TE while simultaneously introducing masking noise to the NTE at the IML.

Step 3: If the patient responds, increase the masking noise in 5 dB or steps, retesting the threshold in the TE.

Step 4: Identify the "plateau"—a range where increasing the masking noise no longer affects the hearing threshold of the TE. This indicates true threshold of the TE.

Step 5: If responses shift, the previous threshold was likely influenced by the NTE, and masking must continue.

A plateau of at least 15dB (i.e., stable TE threshold across 3 successive increases in masking noise) is generally considered acceptable.

Masking Dilemma

If a plateau cannot be reached (i.e., increasing masking always shifts the TE threshold), this may indicate a "masking dilemma", often due to bilateral conductive hearing loss where over masking becomes unavoidable.

If, at this level, there is no response, the pattern may continue without ever reaching a plateau or receiving true masked levels. The masking noise crosses over to the test ear as the test tone increases, creating a masking dilemma.

In this circumstance, the unmasked responses are labelled with an asterisk, and it is stated that masking is not possible without over-masking. This must be done at all frequencies (Perkins & Mitchell, 2025).

Mechanism and Risks in Masking

According to Moginie (2019), under masking is a common error among novice clinicians and students, particularly when masking calculations or interaural attenuation values are not properly applied. Her study introduces a software-based tool to aid in learning effective masking strategies and mitigate the occurrence of under masking. Under masking occurs when the masking noise presented to the non-test ear (NTE) is insufficient to prevent it from detecting the test signal meant for the test ear (TE). More recently, automated and machine-learning approaches have been introduced to reduce human error in masking levels. Wallaert et al. (2024) demonstrated that machine learning-based audiometry tools can effectively maintain masking within safe boundaries, avoiding over-masking while maintaining accuracy in threshold detection (Wallaert et al., 2024).

Zakaria (2022) also highlighted the importance of correctly estimating the minimum interaural attenuation, especially in populations using insert earphones versus supra-aural headphones, where different IA values apply.

Over-masking

Over-masking is a critical concept in pure tone audiometry (PTA), particularly during clinical masking procedures used to isolate the hearing threshold of one ear while preventing cross-hearing via bone conduction. It occurs when the masking noise delivered to the non-test ear (NTE) is so intense that it crosses over and interferes with the test ear (TE), potentially elevating the hearing threshold and leading to inaccurate diagnoses.

The risk of over masking becomes significant when the masking level exceeds the bone conduction threshold of the TE plus the interaural attenuation value (IA). As detailed by Moginie (2019), over masking not only leads to inaccurate audiometric thresholds but also complicates the differential diagnosis of unilateral or asymmetric hearing loss. This error is especially common in students or clinicians unfamiliar with correct masking plateau procedures.

Undermasking

Undermasking is a critical concern in audiology, representing a failure to present adequate masking noise to the non-test ear during audiometric evaluations. This phenomenon occurs when the masking level is insufficient to prevent the non-test ear from perceiving the signal intended for the test ear, resulting in inaccurate threshold recordings and potential misdiagnoses. Undermasking most commonly arises during bone conduction testing or when significant air-bone gaps exist. As early as the 1970s, researchers identified that many audiologists lacked proper training in masking, leading to diagnostic errors and misclassification of hearing loss types (Coles & Priede, 1970). This diagnostic inaccuracy can have profound implications particularly when failing to detect unilateral or asymmetrical hearing loss, which may mask serious conditions like vestibular schwannomas. Perkins and Mitchell (2022) underscore the importance of rigorous masking protocols and illustrate how improper technique can result in masked thresholds being misinterpreted as legitimate hearing acuity.

Despite its significance, undermasking is frequently underemphasized in clinical education. Studies have shown that audiology students often perceive masking as one of the more confusing aspects of their training, especially when applying theoretical concepts in clinical contexts (Skinner et al., 2023). Moginie (2019) demonstrated that simulation-based training significantly improves student understanding and application of masking principles. The persistence of under masking in clinical practice may also stem from overreliance on automated systems without foundational comprehension of interaural attenuation, masking plateau, and central masking effects (Scharf, 1971; Valente, 2009). This emphasizes the need for updated curriculum designs and competency-based evaluations. As Yadav et al. (2021) note, failure to manage masking appropriately even in reverse masking scenarios compromises both diagnostic integrity and patient outcomes. Thus, combating under masking requires a systemic approach: rigorous education, standardized protocols, and clinician accountability.

In early foundational work, Lidén et al. (1959) emphasized the importance of striking a balance between under masking and over masking. They noted that pure-tone audiometry, while invaluable, can be misleading if masking principles are incorrectly applied.

Incorrect application of masking, whether through overmasking or undermasking, can lead to serious clinical misdiagnoses. Coles and Priede (1970) warned that this risk is compounded by the lack of masking familiarity among some practitioners, stressing the need for standardized training and guidelines. Thus, understanding and mitigating over masking is essential for accurate audiological assessment, especially in complex clinical scenarios involving asymmetric hearing or bone conduction masking.

Why Masking?

When a loud tone is presented to one ear, especially in cases of unilateral hearing loss, it can cause vibrations that travel through the skull to the opposite ear. This phenomenon is called crossover, and if the tone is heard in the non-test ear, it's known as cross hearing. Cross hearing can lead to inaccurate test results if the audiologist mistakenly records responses from the wrong ear. For example, a person with complete hearing loss in one ear and normal hearing in the other might seem to have only moderate hearing loss in the poor ear due to the better ear responding to the sounds this is also referred to as shadow hearing.

Effect of Cross Hearing

Incorrect Diagnosis: cross hearing can lead to incorrect audiological diagnoses when sounds presented to one ear are heard by the opposite ear through bone conduction. If proper masking procedures are not applied during audiometric testing, the results can inaccurately reflect the hearing ability of the poorer ear. This is especially common in patients with asymmetric or unilateral hearing loss. The better ear may respond to stimuli meant for the poorer ear, making it seem as though the patient has better hearing in the affected ear than they do. This can result in diagnostic errors such as underestimating the degree of hearing loss or misclassifying the type of hearing loss, leading to inappropriate or delayed interventions.

Embarrassment: when an audiologist fails to identify cross hearing and provides incorrect results, it can lead to professional embarrassment. This is particularly evident when a patient seeks a second opinion and the discrepancies in test results reveal the original oversight. The audiologist's reputation may be questioned, especially in multidisciplinary teams or academic settings where accuracy and precision are paramount. Additionally, explaining the error to patients or colleagues can be uncomfortable and may reduce the patient's confidence in the audiologist's competence. This not only affects the audiologist's morale but can also have long-term consequences on their career and credibility.

Maltreatment or Mismanagement: misdiagnosis resulting from cross hearing can directly lead to the mistreatment or mismanagement of a patient's condition. For example, if a hearing aid is fitted based on incorrect threshold levels, it may amplify sound improperly, causing discomfort or no benefit at all. Similarly, the patient may be referred for treatments or therapies that are unnecessary or ineffective because they are based on faulty data. In severe cases, essential interventions may be delayed or completely overlooked. Such mismanagement not only compromises patient care but can also contribute to deterioration in the patient's auditory, cognitive, or emotional well-being.

Sometimes Unjustified Surgery: in some instances, cross hearing can mislead clinicians into recommending surgery based on flawed audiometric data. For example, if a conductive hearing loss is suspected in an ear that has no response, the patient might be referred for middle ear surgery such as tympanoplasty. Likewise, if a cochlear implant is suggested for an ear presumed to have profound loss, but the testing reflected cross hearing from the better ear, the surgical recommendation becomes unjustified. These unnecessary procedures expose patients to medical risks, financial burdens, and psychological stress, all of which could have been avoided with correct testing and masking techniques.

False Hope: Patients affected by cross hearing may be given inaccurate information about their hearing capabilities, leading to false hope. For instance, a patient might be told that hearing in their poorer ear is better than it truly is, causing them to believe that amplification is not needed. Whereas, solution to the problem lies in the fitting of hearing aid in order to augment the residual hearing. When later assessments or real-life experiences reveal the true extent of their hearing loss, it can result in emotional disappointment and frustration. This misrepresentation of hearing ability may also affect decisions related to career, education, or communication strategies, compounding the patient's challenges. According to Ogundiran and Olaosun (2013), pure tone average is determined by the average of the summation of the three speech frequencies (500Hz, 1000Hz and 2000Hz) for each ear. In an asymmetrical hearing loss, the poorer ear will mimic the pure tone average of the better ear leading to a shadow hearing on the poorer ear, thereby lead to false hope.

Lawsuit: when the consequences of unrecognized cross hearing are severe such as delayed diagnosis in a child, unnecessary surgical intervention, or long-term auditory damage patients or families may resort to legal action. Lawsuits may be filed against the audiologist or the institution for professional negligence or malpractice. Legal consequences are particularly likely if standard masking protocols were not followed or if thorough documentation of procedures is lacking. Apart from financial liability, such legal actions can harm the reputation of the audiologist and the clinic, potentially resulting in license suspension or the loss of professional accreditation

Future Directions in Clinical Masking in Audiology

The future of clinical masking lies in technological innovation, standardization, and expanded accessibility. Artificial intelligence and machine learning algorithms are poised to enhance the precision of masking decisions by analysing large datasets and identifying optimal strategies.

Tele-audiology will continue to grow, necessitating the development of robust remote masking protocols. Paediatric-friendly technologies and child-specific masking approaches are also needed to improve diagnostic accuracy in young patients.

Global standardization of masking protocols can help ensure consistent practice across diverse healthcare systems. Training programs should emphasize masking competency and incorporate the latest research findings.

Looking forward, the integration of artificial intelligence in audiological testing holds promise for enhancing masking accuracy. Artificial intelligence systems can learn from large datasets to optimize masking decisions and adapt protocols based on individual patient characteristics

Ultimately, clinical masking must evolve to meet the changing demands of audiological practice, balancing technical rigor with patient-centred care.

Conclusion

Clinical masking is an essential component of audiological assessment, ensuring the accuracy and reliability of hearing threshold measurements. It is grounded in well-established principles such as interaural attenuation and crossover hearing and is applied across a wide range of diagnostic tests.

Ethical and psychological considerations, as well as the integration of masking into research and paediatric audiology, further underscore its multifaceted role. As the field moves forward, clinical masking will remain a cornerstone of best practice in audiology, requiring ongoing research, education, and refinement.

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