*PROJECT REPORT*

# Computer-based Audiological Evaluation: A Teaching and Training Software

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## Glossary

| SI | Acronyms | |
|---|---|---|
| 1 | B.ASLP | Bachelors of Audiology and Speech-Language Pathology |
| 2 | AC | Air-conduction |
| 3 | BC | Bone-Conduction |
| 4 | IA | Interaural attenuation |
| 5 | $AC_{TE}$ | Air-conduction threshold of test ear |
| 6 | $AC_{NTE}$ | Air-conduction threshold of non-test ear |
| 7 | $BC_{TE}$ | Bone-conduction threshold of test ear |
| 8 | $BC_{NTE}$ | Bone-conduction threshold of non-test ear |
| 9 | $SRT_{TE}$ | Speech recognition threshold of test ear |
| 10 | $ABG_{NTE}$ | Air Bone Gap of non-test ear |
| 11 | OE | Occlusion effect |
| 12 | PB | Phonemically balanced |
| 13 | MCQ | Multiple-choice questions |
| 14 | KBA | Knowledge-based assessment |
| 15 | PMA | Psychomotor assessment |
| 16 | SRT | Speech recognition threshold |
| 17 | SIS | Speech identification scores |

## Abstract

**Background of the study**: In audiological evaluation, the clinical masking comprises of many formulae and rules/ principles that should be mastered before it is used effectively on real patients. Prior to conducting the audiological tests on real patients, novice students trained in classrooms, clinics through observation of audiological evaluation, and repeated practice to master the procedure. This procedure results in a high chance of committing errors and relies on guesswork with no knowledge of the principles. Thus, if the software provides an opportunity to explore these rules/ formula in pictorial representation on a simulated case, it may improve knowledge and psychomotor skills to handle cases in lesser time.

**Objectives:** a) To develop software which simulates audiological profile by using a wide spectrum of patient with hearing impairment.

b) To validate the developed software on second year B.ASLP students using quantitative (Knowledge and psychomotor skills) and Qualitative measures (Usability questionnaire).

**Method:** We initially developed the audiological evaluation software. Later, 15 students from II year B.ASLP (Bachelor of Audiology and Speech-Language pathology) program were selected. These students were tested before and after training with audiological evaluation software on knowledge and psychomotor skills to conduct pure-tone and speech audiometry. Also, each student was asked to fill a standardized questionnaire, which assesses the ease of use, ease of learning, and satisfaction.

**Results:** In post-training condition, significantly higher scores were observed in psychomotor skills and knowledge than the pre-training condition. The time taken to perform the audiological test to handle real and simulated patient was much faster in post-training condition than pre-training. Also, the usability questionnaire was moderately and positively correlated with scores of psychomotor skills to handle real and simulated cases. Furthermore, linear regression was used to predict the benefit received from software on psychomotor skills from the pre-training psychomotor skills.

**Conclusion**: After training with developed software, the knowledge of pure-tone and speech audiometry and psychomotor skills to conduct audiological tests on real and simulated patients improved significantly.

# Chapter 1

## Introduction

In health care education system, the audiology students have to show clinical hours in handling a wide spectrum of clinical cases to obtain clinical competence certificate. Knowledge and skills are required to make an accurate decision on diagnosis. Knowledge refers to information and theoretical aspects of any concept. Whereas, skill refers to the ability to use the information and applying knowledge to a specific context. Students acquire knowledge on an audiological evaluation through classroom teaching, reading books, journals, watching YouTube videos, and monographs, etc. Nowadays, in all these knowledge acquiring modes, an effort has been made to provide a skill-oriented activity. However, merely listening to the lecturer or watching a physical demonstration of a concept cannot install a drive of knowledge transformed into skills until the student has

hands-on experience.

Students are posted in the practical lab and encouraged to learn audiological procedures. This is done to shape students' understanding of the subtle processes involved in the audiological evaluation, boost up their confidence level, time management and provide a platform to manipulate the vaiables and see its effects. Also, the student plays role reversal activity that is playing the role of patient and often practices on each other (ear is occluded to simulate conductive hearing loss) for training and interaction purpose. However, in the practical lab, students are unable to experience audiological findings of a range of cases and pattern of results from a battery of tests. It is observed in the clinic that the majority of the students'experience difficulty in performing masking. It comprises of many formulae and rules to obtain genuine threshold from test ear by avoiding the participation of non-test ear.

Even though students are provided orientation in classrooms and clinical practice, at times, a few students are stressed to apply the masking formula on clients in the clinic. This is majorly due to lack of exposure to cases in the lab, making the student under-confident to handle patients in the clinical situation.

Simulated software in a lab environment provides an experience on the behavioural response of the patient, courses of action concerning the response, safety, and efficient method before they handle real cases. Usage of software depends on the working environment as it should be user-friendly and self-explanatory (Lee and Lee, 2004). Besides, software should take students' experience into the tour of realism by incorporating the feeling of anticipation, clinical reasoning, and decision making (Thwaites et al., 2008). Moreover, software should provide valuable preparatory work before handling real cases. Hubal & Frank (2007) developed a battle filed simulator for safe practice and to improve tactical skills. The users have reported that battle filed simulator provided a realistic experience without the expense of time and victims. The users also appreciated the experience of owing to great sensitivity to small changes in conditions and identification of their mistakes by playing repeatedly. It provides a platform to replay the situation, record the response, and retrospect the approach for the activity, which gives them feedback and aid in decision analyses. Simulated software is being popularly used to train doctors, teaching social skills for children diagnosed with autism, nursing education, etc., (Fabri et al., 2007; Shea et al., 2003; Hildner, 2007). Visual characters (VC) interfaced with a computer are introduced in edutainment for training (Foroughi, 2006). Garzotto and Forfori (2006) used visual characters in virtual mode to teach grammar and construction of sentences to children. The results revealed that children showed increasing interest, motivation, and confidence. Also, the options for changing the role and personality of visual characters' increases user confidence level (Hubal & Frank, 2007). Forsberg, Georg, Ziegert, and Fors (2011) investigates nursing student opinion about the feasibility of virtual characters for assessing clinical reasoning. Their students who are involved in using clinical software appreciated the realism and accepted the experience of clinical reasoning. In yet another study, Botezatu, Hult, Tessma, and Fors (2010) used VCs and traditional method to train bachelor of medicine students on haematology and cardiology topics in an internal medicine course. The results indicated better retention with VP than with the conventional methods. In the field of audiology, Lieberth and Martin (2005) conducted a study by comparing the student training on pure tone audiometry using audiometer, and a virtual audiometer. Their results revealed both groups of students received similar grades but the students who have used virtual audiometer have showed upper hand in interactions and feedback with the patient. However, access to simulated software is costlier, and it cannot be customized for clinician and student training.

Thus, it is utmost essential to develop software which simulates the audiological profile. The developed software provides a simulated platform for the student to experience frequently found findings before handling clinical patients (Minocha & Reeves, 2010) and also enhances their clinical skills ( Johnsen & Raij, 2005). Also, repeated trial and feedback allows the students to realize their mistakes and rectify themselves (Billings, 2012). Further, the faculty can also use this developed software as an additional teaching material which utilizes animation and illustrations. The use of this software will boost up students clinical reasoning, decision making, confidence level (Baylor & Kim, 2009) and swift reaction towards a problem that may arise in real-time (Husén &Postlethwaite, 1994). Thus, the software developed can be used effectively by novice undergraduate students and the faculty.

**Need for the study**

The classroom teaching on *audiological evaluation* on a range of cases within a short period of time restricts the acquisition of necessary skills to handle a case. Students are posted in the laboratory setup where they are well trained with clinical procedures using instruments. However, exposure to clinical cases and or simulating cases at the laboratory setup is merely impossible. Though the students are posted in a practical lab to learn clinical procedures of audiology, experiencing a variety of cases are merely impossible. This makes the student be in the dark until they have to handle cases in a clinical setup. Eventually, students lack clinical experience in the way patients respond in reality. These factors put the clinicians in a state of under confidence while dealing with patients in the clinic.

It is observed that students are confused at times to use a set of rules, mainly clinical audiological masking. Also, a situation may arise in the clinical setting that would be new to them as they are not exposed to such a scenario earlier in the lab. These factors may lead to committing mistakes. A mistake is inevitable while learning, but the same mistake is costlier on patients. Besides, it is observed that novice students take extra time than usual to complete the audiological evaluation. This leads to prolonged waiting time for the patients in line for the hearing evaluation, which is repeatedly reported in patient feedback. This results in a delayed appointment of audiological assessment for new cases.

Thus, the above-mentioned glitches on both students and patient sides are definitely reduced if the students are trained using application ***software which simulates audiological profiles*** at a lab environment. It provides an environment for the students to experience a high level of realism. Students inevitably link a learned theoretical knowledge in the classroom set up with the knowledge experienced from simulated cases through the software. This helps the student to have a stress-free environment in the learning process. Also, the software throws a pop up message if the students commit a mistake and provide a cue to rectify the error made by them. This experience would always prod them to take the correct decision when they are handling real patients. The software provides a chance for all the students to be equipped to handle even less frequent cases. These learned skills using software will surely reduce the mistake and consequently takes less time to handle an actual patient. Thus, there is a need to develop software which simulates audiological profiles by wide spectrum of cases.

**Aim of the study**

The study aimed to develop clinical audiological evaluation training software. Further, it was also aimed to document the training effect and usefulness of developed software with the bachelor students of audiology.

**Objectives of the study**

1. To develop the software which simulates the audiological profile by using a wide spectrum of clients with hearing impairment.
2. To validate the developed software on second-year B.ASLP students, using qualitative and quantitative measures.
    a. To compare scores before and after training on
        i. knowledge of audiological skills
        ii. psychomotor skills of handling real and simulated patients with hearing impairment
        iii. the time taken to complete audiological evaluation of patients with a simulated hearing impairment.

b. To correlate each component of the usability questionnaire (qualitative measure) with scores of psychomotor skills of students in handling the simulated patient and real patient.

c. To correlate the psychomotor skills between pre-training and benefit received from software in handing simulated patient and real patient

d. To predict the benefit of psychomotor skills of audiological evaluation from the score of pre-training psychomotor skills.

# Chapter 2

# Methods

The present study aimed to develop the audiological evaluation software to train the students to handle the accurate procedure of audiological test on clinical patient s in laboratory (virtual) settings. The study was carried out in two phases. Phase I involved the development of 'Audiological evaluation training software in simulated mode,' and Phase II focused on validation of developed software on second-year B.ASLP (Bachelors of Audiology and Speech-Language Pathology) students using qualitative and quantitative measures.

## Phase I: Development of the software

A computer-based audiological evaluation training software in simulated mode was developed by creating the database using Microsoft access, which in turn interfaced with the application using Visual Studio (version -1) software. The software development comprised of two levels: a) database preparation (Level 1) and b) interfacing of the database to the application software (Level 2).

**Level 1: Database preparation**. Database preparation dealt with the organization of data, in which the software can retrieve the data when students are working with the software. In this section, the procedure utilized to prepare the database for each of the tests such as AC, BC, Weber, SRT, and SIS were explained at the respective heading.

Data is operationally defined as the intensity levels of corresponding correct and incorrect responses given by the patients in the pure tone audiometry. The behavioural responses of each test are used to help decision-making, and this information is stored in an electronic form. The data points of every response and no response until the arrival of the threshold for each test were considered for the preparation of the database.

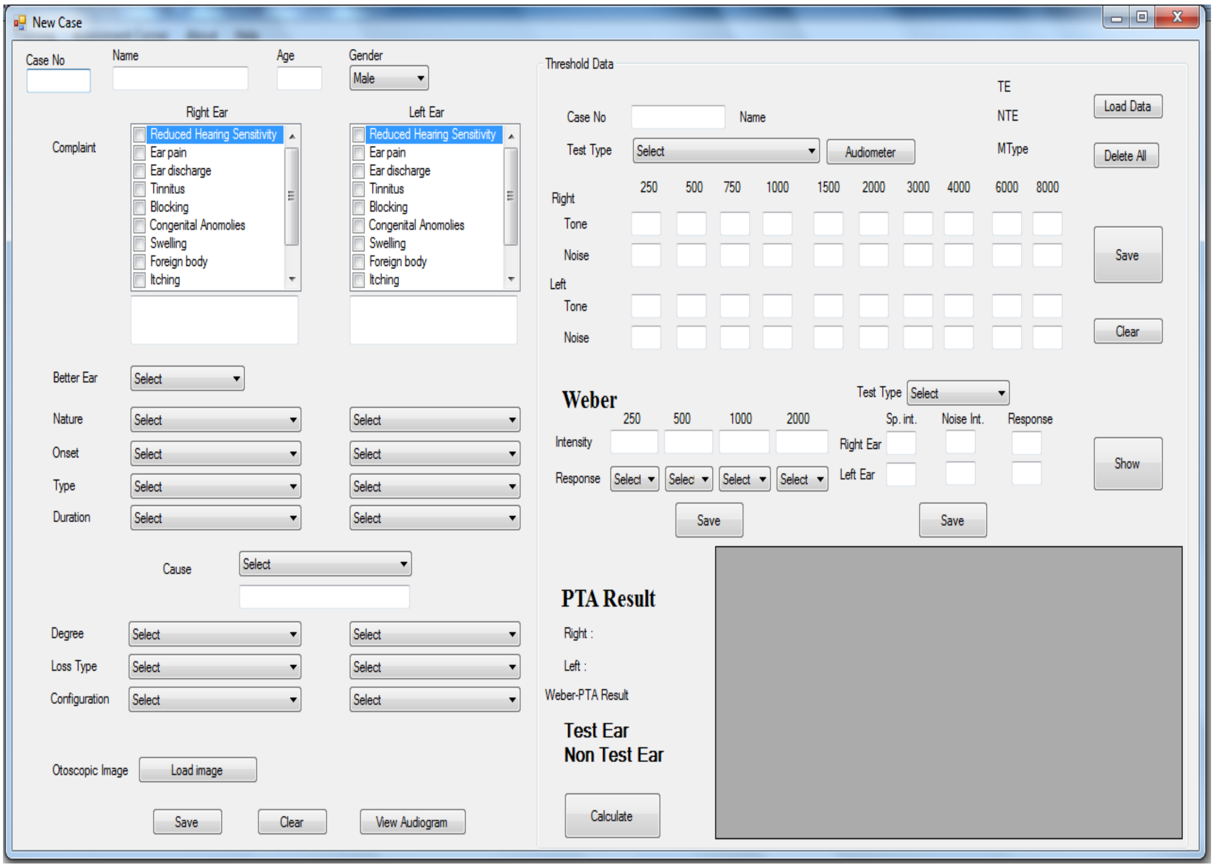


*Figure 2.1. Represents database page in the software to load the information from each client.*

The demographic details (case number, name, age and gender) were entered in the software. Complaints specific to the ear were selected from the drop down menu. The other details loaded were regarding the nature, onset and duration of the hearing loss. Also, the otoscopic image of each of the ears was uploaded (Figure- 2.1). In database page, the 'audiometry' option was selected to load the data of the response and no response till the arrival of pure tone threshold for AC (250 to 8 kHz) and BC (250 Hz to 4 kHz) at each frequency in each of the ears separately (Figure- 2.2). In ‘audiometry’ data page, the ear, mode of testing (AC/ BC), and conditions (unmasked/, masked) were selected. Further, the test frequency and initial testing was selected in the unmasked state. If the client detects the tone, then response ‘yes' was assigned, else ‘no' was allocated. The intensity levels of response ‘yes’ and no response ‘no’ until the arrival of threshold were stored. The above procedure was followed for each frequency in both AC and BC modes, separately, for both the ears. If masking was required, then the responses of either ‘yes' or ‘no' at the set intensity level until the arrival of the masked threshold were stored. The detailed procedure on the preparation of database for pure tone audiometry is described.

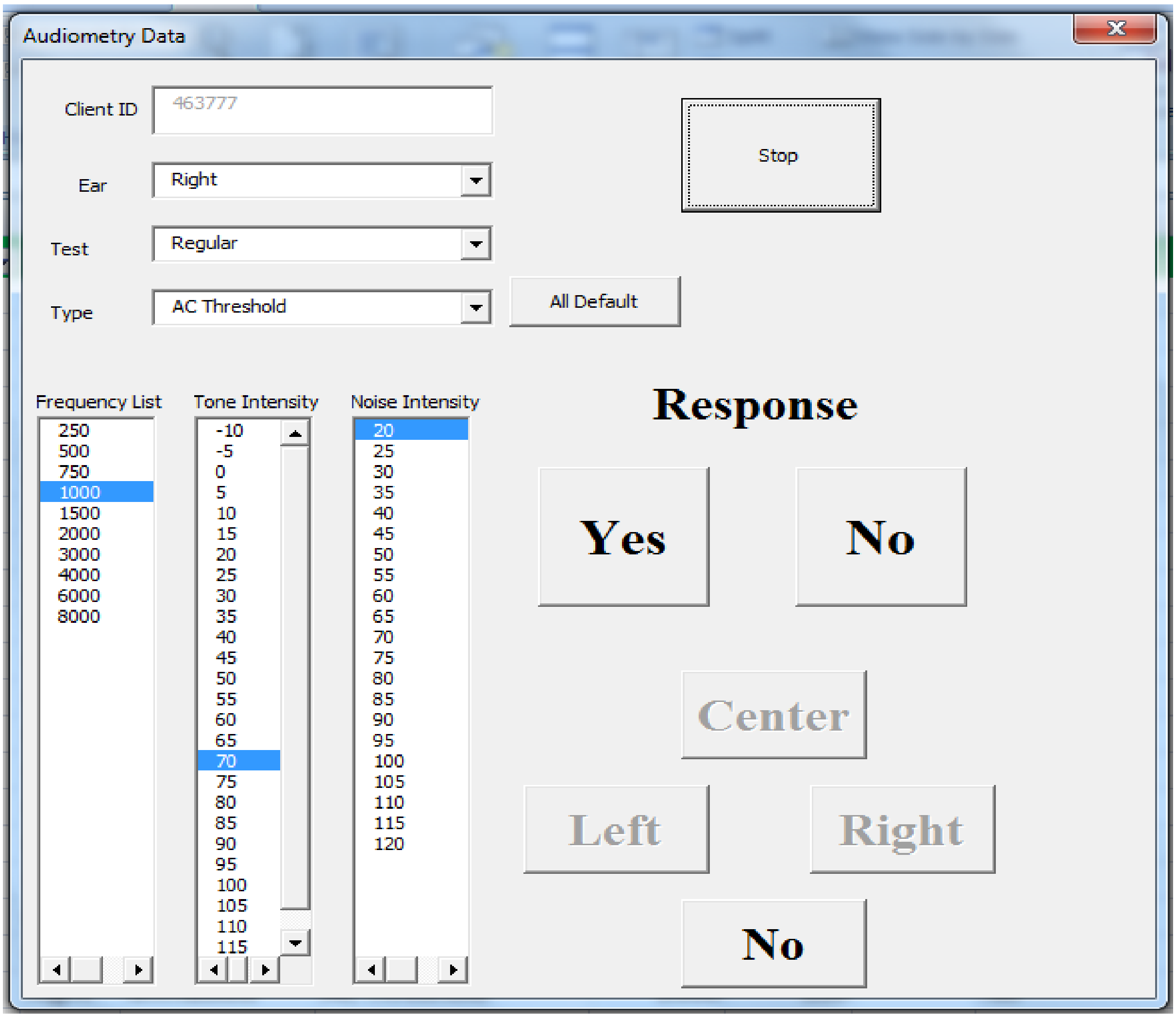


*Figure 2.2 Window showing the preparation of database for pure tone audiometry*

***Unmasked air-conduction and bone-conduction testing.*** Modified Hughson and Westlake procedure (Hughson& Westlake, 1944) was utilized to track the air- (0.25 kHz to 8 kHz in octave) and bone- (0.25 kHz to 4 kHz in octave) conduction thresholds. Mid-octave frequency testing was included if the threshold differences between two adjacent octave frequencies are greater than 20 dB HL. The intensity was decreased by 10 dB if the client detects the tone, and it is annotated as 'yes' in the software. The intensity level was increased by 5 dB if the client unable to detect the tone and it is labelled as 'no' in the software. The threshold was considered as the lowest intensity at which a minimum of two positive responses ('yes') was obtained. The thresholds in both air- and bone- conduction modes were obtained. At each frequency, data points of every 'yes' and 'no' response of the corresponding intensity level at the starting level till the arrival of threshold were loaded in the database (Figure- 2.3).

Data points for every 'yes' and 'no' response for AC testing at 1000 Hz is given in Table 2.1. A positive response 'yes' was obtained at 70 dB HL. Hence intensity was decreased by 10 dB, and testing was carried at 60 dB HL. The intensity of the tone was reduced in 10 dB step size until the first negative response was obtained from the client. At 40 dB HL the first negative response was obtained; hence intensity was increased by 5 dB and testing was carried out at 45 dB HL. This 10 dB down and 5 dB up step-size was carried out until the threshold was achieved. In the present example, 45 dB HL is considered as the threshold because 45 dB is the lowest level at which the patient has given two positive responses.

Table 2. 1. Data points of the 'Yes' or 'No' response during AC testing at 1000 Hz

| **Intensity (dB HL)** | **Response** |
|---|---|
| 70 | Yes |
| 60 | Yes |

| | |
|---|---|
| 50 | Yes |
| 40 | No |
| 45 | Yes |
| 35 | No |
| 40 | No |
| 45 | Yes |

| ID | CaseNo | Ear | TestType | Frequency | StimulusIntensit | NoiseIntens | Response | EntryDate | Add New Field |
|---|---|---|---|---|---|---|---|---|---|
| 1768 | 474766 | Right | UnMasked BC | 2000 | 0 | | | 07/26/2018 | |
| 1769 | 474766 | Left | UnMasked BC | 2000 | 0 | | | 07/26/2018 | |
| 1770 | 474766 | Right | UnMasked BC | 4000 | -5 | | | 07/26/2018 | |
| 1771 | 474766 | Left | UnMasked BC | 4000 | -5 | | | 07/26/2018 | |
| 1772 | 474766 | Nil | Weber | 250 | 5 | | Right | 07/26/2018 | |
| 1773 | 474766 | Nil | Weber | 500 | 10 | | Right | 07/26/2018 | |
| 1774 | 474766 | Nil | Weber | 1000 | 10 | | Right | 07/26/2018 | |
| 1775 | 474766 | Nil | Weber | 2000 | 5 | | Right | 07/26/2018 | |
| 1776 | 474766 | Right | Masked BC | 250 | 0 | | | 07/26/2018 | |
| 1777 | 474766 | Left | Masked BC | 250 | | 25 | | 07/26/2018 | |
| 1778 | 474766 | Right | Masked BC | 500 | 5 | | | 07/26/2018 | |
| 1779 | 474766 | Left | Masked BC | 500 | | 30 | | 07/26/2018 | |
| 1780 | 474766 | Right | Masked BC | 1000 | 5 | | | 07/26/2018 | |
| 1781 | 474766 | Left | Masked BC | 1000 | | 20 | | 07/26/2018 | |
| 1782 | 474766 | Right | Masked BC | 2000 | 0 | | | 07/26/2018 | |
| 1783 | 474766 | Left | Masked BC | 2000 | | 20 | | 07/26/2018 | |
| 1784 | 474766 | Right | Masked BC | 4000 | 5 | | | 07/26/2018 | |
| 1785 | 474766 | Left | Masked BC | 4000 | | 20 | | 07/26/2018 | |
| 1786 | 200003 | Right | UnMasked AC | 250 | 50 | | | 07/26/2018 | |
| 1787 | 200003 | Left | UnMasked AC | 250 | 60 | | | 07/26/2018 | |
| 1788 | 200003 | Right | UnMasked AC | 500 | 40 | | | 07/26/2018 | |
| 1789 | 200003 | Left | UnMasked AC | 500 | 80 | | | 07/26/2018 | |
| 1790 | 200003 | Right | UnMasked AC | 1000 | 45 | | | 07/26/2018 | |

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*Figure 2. 3. Showing the database for pure tone audiometry.*

***Audiometric Weber test.*** Audiometric Weber test was selected (Figure-2.1). It was performed at the octave frequencies from 0.25 kHz to 2 kHz. The patient was instructed to indicate the side in which (Right, left, and center) the tone was heard. The starting intensity level was -10 dB. Yes/no responses were recorded at every level. For every ‘no’ response (inaudibility), the intensity was increased by 5 dB, and testing was carried out. Intensity was increased until ‘yes' (audibility and lateralization) response was elicited from the patient. If the patient reported that the tone was audible from the right side, then the right lateralization response ‘R’, and similiarly for the left lateralization response 'L'.  If the patient could not lateralize the tone to either of the ears, or if it was heard at the centre, then the response recorded was centre 'C'. The intensity level at which the tone was lateralized at each frequency was noted in the database (Figure- 2.3).

At 1000 Hz frequency (Table 2.2), the patient was unable to hear at -10 dB HL, hence the intensity was increased in 5 dB step-size until patient was able to hear the tone. At 10 dB HL, the patient heard the tone from the right side. Hence, lateralization response in the right ear at 10 dB HL was entered in the database. Similarly, the lateralization response obtained at other frequencies is documented in the database.

*Table 2. 2. Data points of the ‘Yes’ or ‘No’ of the audiometric Weber test at 1000 Hz*

| **Intensity (dB HL)** | **Response** |
|---|---|
| -10 | No |
| -5 | No |
| 0 | No |
| 5 | No |
| 10 | Yes |

***Masking.*** Masking criteria Liden, Nilsson, and Anderson (1959) and the plateau method were used to test during AC and BC masking. Table 2.3. summarizes the masking criteria and the formula used for masking in pure- tone audiometry and speech audiometry (Yacullo, 1999).

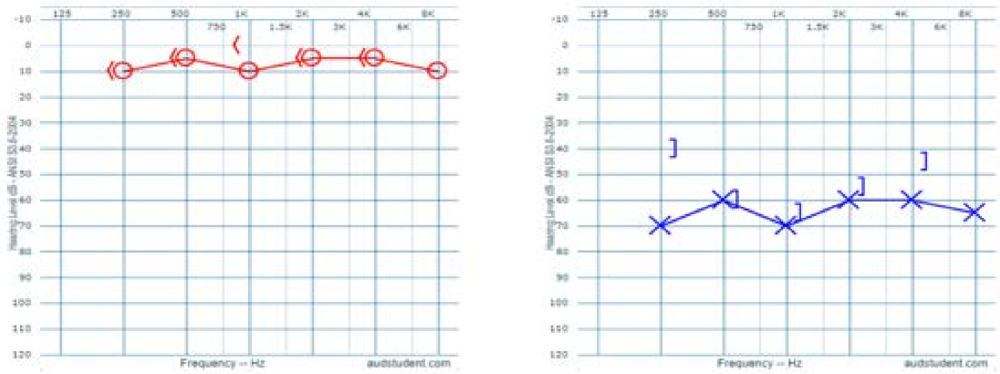
*Table 2. 3. Masking criteria and noise levels during pure-tone and speech audiometry.*

| **Audiological Measures** | **When to mask** | **Minimum masking noise** | **Maximum masking noise** |
|---|---|---|---|
| Bone-conduction thresholds | $AC_{TE}$ - $BC_{NTE}$ ≥ 10 | $BC_{TE}$ +$ABG_{NTE}$<br>OR<br>$BC_{TE}$ +$ABG_{NTE}$ + O.E<br>O.E of 10 dB is added to 250 Hz and 500 Hz when $ABG_{NTE}$ is less than 20 dB | $BC_{TE}$ + IA – 5 |
| Air-conduction thresholds | $AC_{TE}$ - $BC_{NTE}$ ≥ 40 | $AC_{TE}$ - 40 + $ABG_{NTE}$ | $BC_{TE}$ + IA – 5 |
| Speech Recognition Threshold (SRT) | Unmasked $SRT_{TE}$ - Best $BC_{NTE}$ ≥ 40 | $PL_{TE}$ – IA + Largest $ABG_{NTE}$<br>$PL_{TE}$ = Unmasked $SRT_{TE}$ | $BC_{TE}$ + IA – 5 |
| Speech Identification Scores (SIS) | Masked $SRT_{TE}$ - Best $BC_{NTE}$ ≥ 40 | Masked $SRT_{TE}$ -20 | $BC_{TE}$ + IA – 5 |

Note: $AC_{TE}$ = air-conduction threshold of test ear; $AC_{NTE}$ = air-conduction threshold of non-test ear; $BC_{TE}$ = Bone-conduction threshold of test ear; $BC_{NTE}$ = Bone-conduction threshold of non-test ear, $SRT_{TE}$ = Speech recognition threshold of test ear; $ABG_{NTE}$ = Air Bone Gap of non-test ear; OE = Occlusion effect; IA = Interaural attenuation. IA was considered based on the transducer used in the testing.

***Plateau procedure for masking in pure-tone audiometry.*** The minimum amount of noise was calculated (Liden, 1959).

The tone was presented at the level of unmasked threshold of the test ear (either AC or BC). Narrowband noise (NBN) corresponding to the frequency of the tone was presented in the non-test ear. For every response ‘yes’ (when the patient indicates the presence of tone in noise) the intensity of noise was increased by 5 dB, and for every response ‘no’ (when the patient indicates the absence of tone in noise) the intensity of tone was increased by 5 dB. This procedure is continued until a plateau is achieved, that is, obtaining three responses ‘yes’ for three consecutive increase in noise levels. The intensity level of the tone at which three responses ‘yes’ were achieved for three successive increases in noise level was considered as the masked threshold. Data points for every ‘yes' and ‘no' response for corresponding noise and tone levels were stored in the database. An example has been worked out for masking criteria of minimum and maximum noise calculation for plateau procedure for BC masking for 1000 Hz (Figure 2.4).



| | Unmasked SRT | Masked SRT | Unmasked SIS | Masked SIS |
|---|---|---|---|---|
| Right Ear | 5 | - | 100 % | - |
| Left Ear | 65 | 75 | 92 % | 76 % |

*Figure 2. 4: An audiogram of the patient with unilateral severe sensorineural hearing loss*

The intensity level of tone and noise corresponding to the response ‘yes’ and no responses ‘no’ from a client to obtain masked BC threshold at 1000 Hz are tabulated in Table 4. In ‘audiometry' data page, the ear, mode of testing (BC), and conditions (masked) were selected (Figure-2.2). The minimum noise level was obtained by subtracting inter-aural attenuation from $BC_{NTE}$ (Liden et al., 1959) (Ex. 5-0 +10 = 15). Hence minimum noise level of 15 dB HL was set initially and presented in the non-test ear (i.e., the left ear). The patient was unable to detect the tone which was set at 10 dB HL. Thus, the tone level was increased by 5 dB in the successive trail. For the next five consecutive trials, a client gave a response ‘no’. Thus the tone was increased in steps of 5 dB for each response ‘no’ (unable to detect the tone). The first response was obtained for the tone presented at 45 dB HL in the presence of 15 dB noise in the contralateral ear. Since the client had detected the tone, the level of intensity of noise was increased by 5 dB, and the patient response was sought. Likewise, the tone was increased for every ‘no’ response (unable to detect the tone), and the noise was increased for every ‘yes’ response (detect the tone). This was done until the patient gave the response for three consecutive increases in noise levels of 5 dB step size in each. In the present example, at 75 dB HL the patient gave response ‘yes’ for three consecutive increase in noise levels (from 30 to 40 dB) (Table-2.4). Likewise, the masked threshold at other frequencies for BC (0.25 to 4 kHz in octave) and AC (0.25 to 8 kHz in octave) were obtained, if the masking criteria satisfied as specified in Table 2.3.

The intensity level of tone and noise from the initial level to the threshold for AC and BC at every frequency was stored in the database.

*Table 2. 4. ‘Yes’ or ‘No’ response for corresponding tone and noise levels are shown to obtain masked BC threshold for 1000 Hz*

| **Tone level in test ear (right ear) dB HL** | **Noise level dB HL** | **Response** |
|---|---|---|
| 10 | 15 | No |
| 15 | 15 | No |
| 20 | 15 | No |
| 25 | 15 | No |
| 30 | 15 | No |
| 35 | 15 | No |
| 40 | 15 | No |
| 45 | 15 | Yes |
| 45 | 20 | No |
| 50 | 20 | No |
| 55 | 20 | No |
| 60 | 20 | No |
| 65 | 20 | No |
| 70 | 20 | No |
| 75 | 20 | Yes |
| 75 | 25 | Yes |
| 75 | 30 | Yes |

***Speech Recognition Threshold Testing (SRT).*** Bracketing method (Hughson & Westlake, 1944) was adopted for estimating the Speech Recognition Threshold (SRT)**.** SRT testing was carried out for each ear separately. The initial intensity level of speech for SRT testing was set at 20 dB SL (ref. PTA). If a patient gives a positive response, i.e., two out of four spondees are repeated correctly, then the intensity was decreased by 10 dB. Conversely, if the patient gave a negative response, i.e., correctly repeated less than two out of four spondees, then the intensity was increased by 5 dB. The 10 down/ 5 up procedure continued until the threshold was reached. The threshold is defined as the lowest intensity level at which a patient correctly repeats two spondees out of three spondees. The responses and intensity from the initial level to the SRT was saved in the database (Figure 2.5).

| Client ID | Date | Ear | Condition | Testing | | Intensity | Intensity | Response |
|---|---|---|---|---|---|---|---|---|
| 463637 | 13/12/2017 | Right | Unmasked | SRT | | 100 | | Yes |
| 463637 | 13/12/2017 | Right | Unmasked | SRT | | 90 | | Yes |
| 463637 | 13/12/2017 | Right | Unmasked | SRT | | 80 | | No |
| 463637 | 13/12/2017 | Right | Unmasked | SRT | | 85 | | No |
| 463637 | 13/12/2017 | Right | Unmasked | SRT | | 90 | | Yes |
| 463637 | 13/12/2017 | Right | Unmasked | SIS | | 100 | | 76% |
| 463637 | 13/12/2017 | Left | Unmasked | SRT | | 85 | | Yes |
| 463637 | 13/12/2017 | Left | Unmasked | SRT | | 75 | | Yes |
| 463637 | 13/12/2017 | Left | Unmasked | SRT | | 65 | | No |
| 463637 | 13/12/2017 | Left | Unmasked | SRT | | 70 | | Yes |
| 463637 | 13/12/2017 | Left | Unmasked | SRT | | 60 | | No |
| 463637 | 13/12/2017 | Left | Unmasked | SRT | | 65 | | No |
| 463637 | 13/12/2017 | Left | Unmasked | SRT | | 70 | | Yes |
| 463637 | 13/12/2017 | Left | Unmasked | SIS | | 100 | | 88% |
| 463637 | 13/12/2017 | Right | Masking | SRT | | 100 | 95 | Yes |
| 463637 | 13/12/2017 | Right | Masking | SRT | | 90 | 95 | No |
| 463637 | 13/12/2017 | Right | Masking | SRT | | 95 | 95 | No |
| 463637 | 13/12/2017 | Right | Masking | SRT | | 100 | 95 | yes |
| 463637 | 13/12/2017 | Right | Masking | SIS | | 100 | 100 | 60% |
| 465342 | 14/12/2017 | Right | Unmasked | SRT | | 30 | | Yes |
| 465342 | 14/12/2017 | Right | Unmasked | SRT | | 20 | | Yes |
| 465342 | 14/12/2017 | Right | Unmasked | SRT | | 10 | | No |

*Figure 2. 5. Showing the database for speech audiometry.*

***Speech Identification Score (SIS).*** SIS testing was performed for each of the ears separately at the initial set intensity at 40 dB SL (Ref. SRT). If the initial set intensity exceeds

100 dB, especially in client with PTA greater than 61 dB of hearing loss, then their MCL was identified to present the spondees. Twenty-five bisyllabic words for the PB word list were presented sequentially. Percentage score for correctly repeated words out of 25 PB words was stored in the database.

***Masking for speech audiometry.*** Masking criteria for SRT and SIS was followed according to Liden et al. (1959), whereas masking noise level was calculated using the simplified method given by Yacullo (1999). Table 3 summarizes the masking criteria and formula used for speech audiometry.

***Masked speech recognition threshold.*** If the difference between unmasked $SRT_{TE}$ and best $BC_{NTE} \geq 40$ dB, then SRT masking is required. The *minimum masking noise level* was calculated as unmasked $SRT_{TE} - IA + ABG_{NTE}$ (Liden et al. 1959). The noise used was speech shaped noise. The minimum noise level was presented in the non-test ear, and four spondees or bisyllabic words were delivered sequentially at the unmasked SRT of the test ear. The patient was instructed to repeat the spondaic word in the presence of noise. A positive response is considered when the patient correctly repeated at least two out of four spondees in the presence of noise. However, if the patient correctly repeated one spondee or was unable to repeat the spondees in the presence of noise, then the response was considered as negative. For every positive response, the intensity of noise was increased by 5 dB; and for every negative response, the intensity level of spondees or bisyllabic words was increased by 5 dB. This procedure was followed until the plateau was achieved. SRT was considered as the lowest level at which positive response was obtained, with three consecutive increases in noise levels. Data on the response (recognition of spondees) and corresponding intensity level for speech and noise from the initial set intensity level till the SRT were documented in the database (Figure-2.5).

Table 2.5 illustrates the data point obtained during SRT. The starting noise level was set at a minimum noise level (35 dB HL), and spondees were presented at the unmasked SRT level (65 dB HL). The negative response was obtained for the initial set level. Hence, the intensity level of spondee was increased by 5 dB. For the second trial (spondaic words presented at 70 dB HL in the presence of 35 dB noise), the patient gave a positive response, hence noise level was increased by 5 dB. Likewise, the intensity of noise in non-test ear and spondee in test ear were varied until the threshold was achived. At 70 dB HL, the patient gave a positive response for three consecutive increases in noise level (from 35 to 45 dB HL). Hence, 75 dB HL was considered as masked SRT.

*Table 2. 5. 'Yes' or 'No' response for corresponding tone and noise levels are shown to obtain masked speech recognition threshold.*

| Tone level in test ear (right) dB HL | Noise level dB HL | Response |
|---|---|---|
| 65 | 35 | No |
| 70 | 35 | Yes |
| 70 | 40 | Yes |
| 70 | 45 | Yes |

***Masking for speech identification scores.*** If the difference between masked SRT $_{TE}$ and best $BC_{NTE}$ ≥ 40 dB, then SIS masking was required. In this simplification method, the initial masking level was calculated by masked $SRT_{TE}$-20 (Yacullo, 1996). The noise used was speech shaped noise. The non-test ear received a constant level of noise, and a list of 25 PB words were presented sequentially at 40 dB SL (ref. masked $SRT_{TE}$) in test ear. The patient was asked to repeat the words heard. The number of words repeated correctly was noted and converted into a percentage score and was considered as the SIS. This score was stored in the database.

The data from a range of rare and frequent cases were stored in the database for each test. The student has to select the client on whom the audiological evaluation can be visualized. The audiological profile from the database is retrieved, and it is accessed through the interface software.

**Level 2: Interface of the database with application software.** The masked and unmasked thresholds for every frequency for pure tone and speech audiometry were available in the database. The database should be uploaded in the application software for later retrieval of data points of the case selected by the beneficiary. The instructions and pop-up messages for incorrect selection of keys in the software under each test are given in Appendix II.

***Pure-tone audiometry.*** To carry out air-conduction pure-tone audiometry, the user has to select ‘air' under transducer and ‘tone' under the stimulus. Whereas, for bone-conduction testing, the user has to select ‘bone' under the transducer and ‘tone' under the stimulus. The user can select either ‘right’ or ‘left’ to present the stimulus from audiometer. After selecting the desired frequency, the interrupter button is used to increase and decrease the intensity. The response was indicated by thumbs-up and -down icon, corresponding to the data point of patient selected by the user (Figure- 2.6).

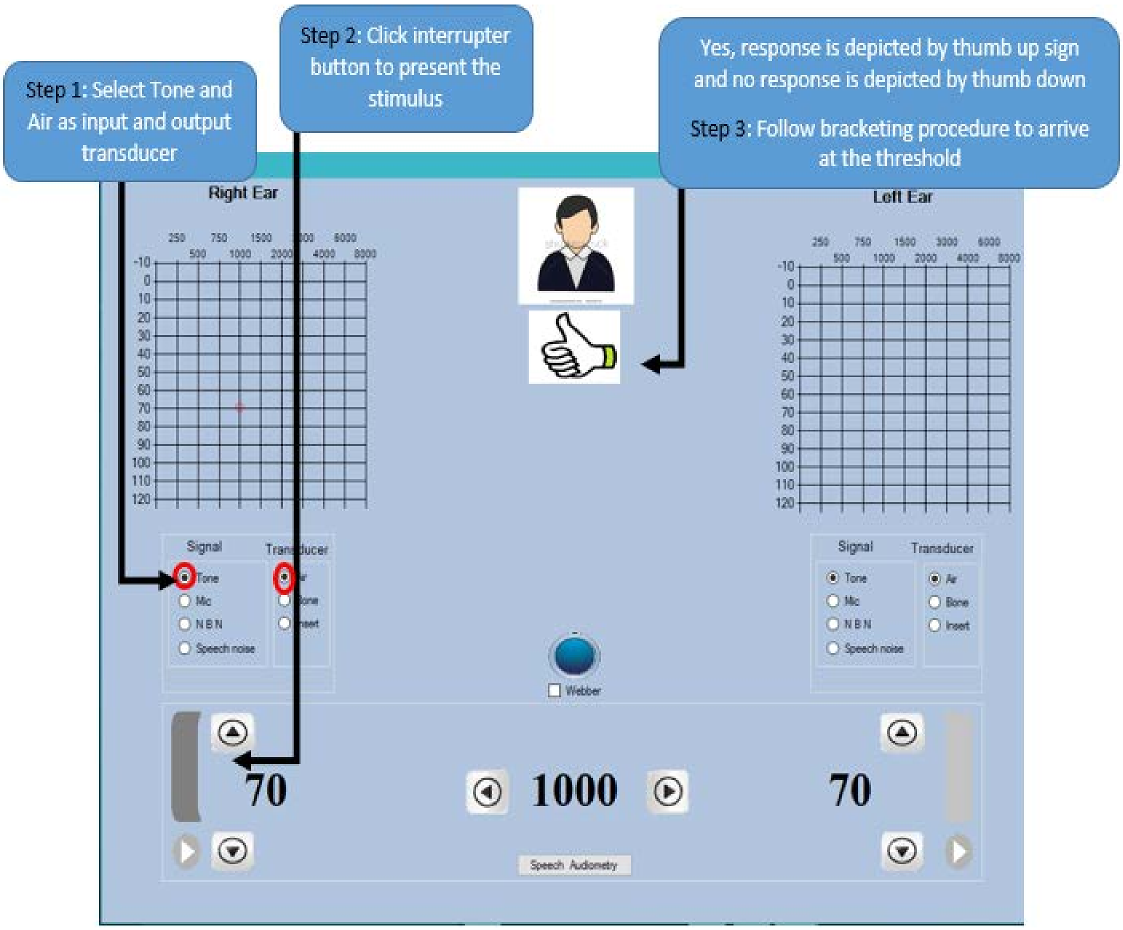



*Figure 2. 6. Represent pure tone audiometry module in the software.*

To obtain the masked threshold, the user should select options under signal and transducer in each of the channels. The transducer in the test ear and non-test ear should be selected to deliver tone in the test ear and NBN in the non-test ear. The user should set the correct initial intensity levels in both the channels, that is, the minimum noise level in the non-test ear and unmasked threshold in test ear (Figure 2.7). Pop-up messages are provided for the a) incorrect initial levels, b) incorrect selection of test ear and non-test ear and c) incorrect plateau procedure. The response to the tone in the presence of noise is indicated by thumbs-up and -down, corresponding to the data point of the patient selected by the user.

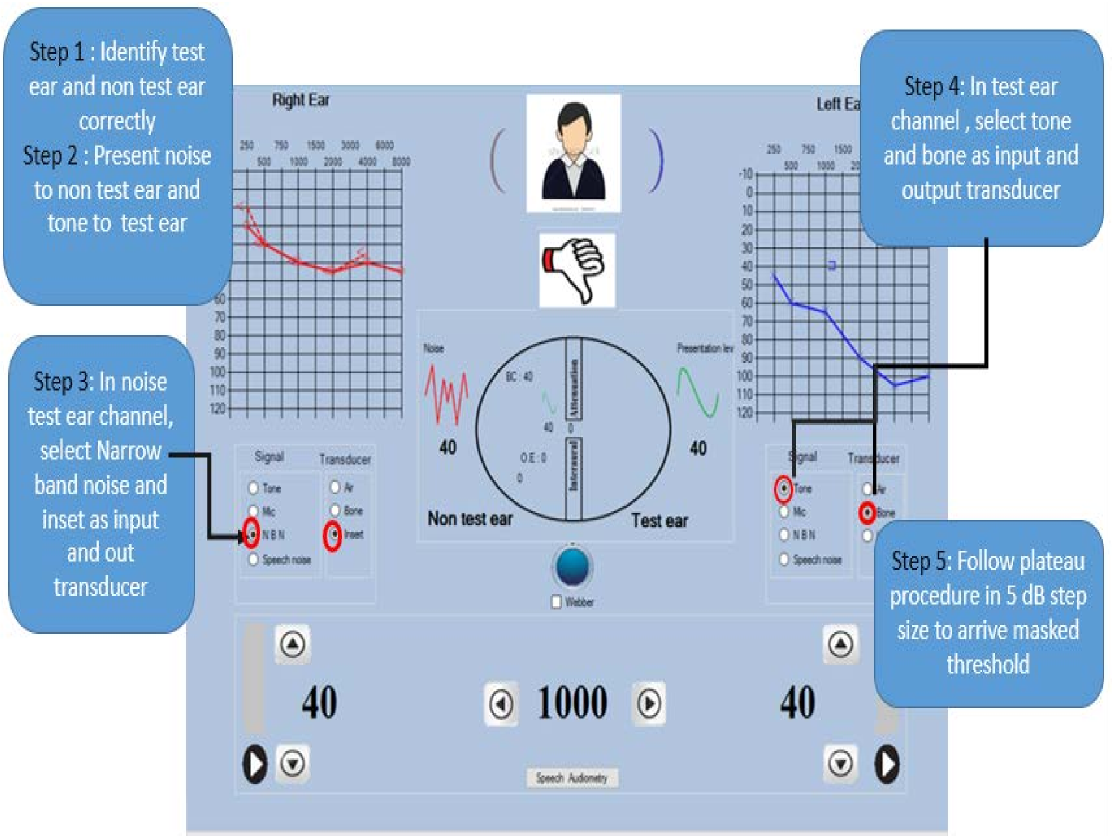



*Figure 2. 7. Represent masking in the pure tone audiometry module in the software.*

***Speech audiometry.*** Figure 2.7 represents SRT masking in speech audiometry module in the software. The user should click on the checkbox to select SRT testing; he/she has to opt input transducer (mic), an output transducer (air) and stimulus (spondee). With three spondees selected, the interrupter button should be pressed to deliver it sequentially through the selected transducer. If according to the criteria masking is required, then speech masking noise level calculated from formula has to be set in NTE, which is delivered through the insert receiver. An increase or decrease of intensity was made corresponding to the data point stored for the case selected by the user.

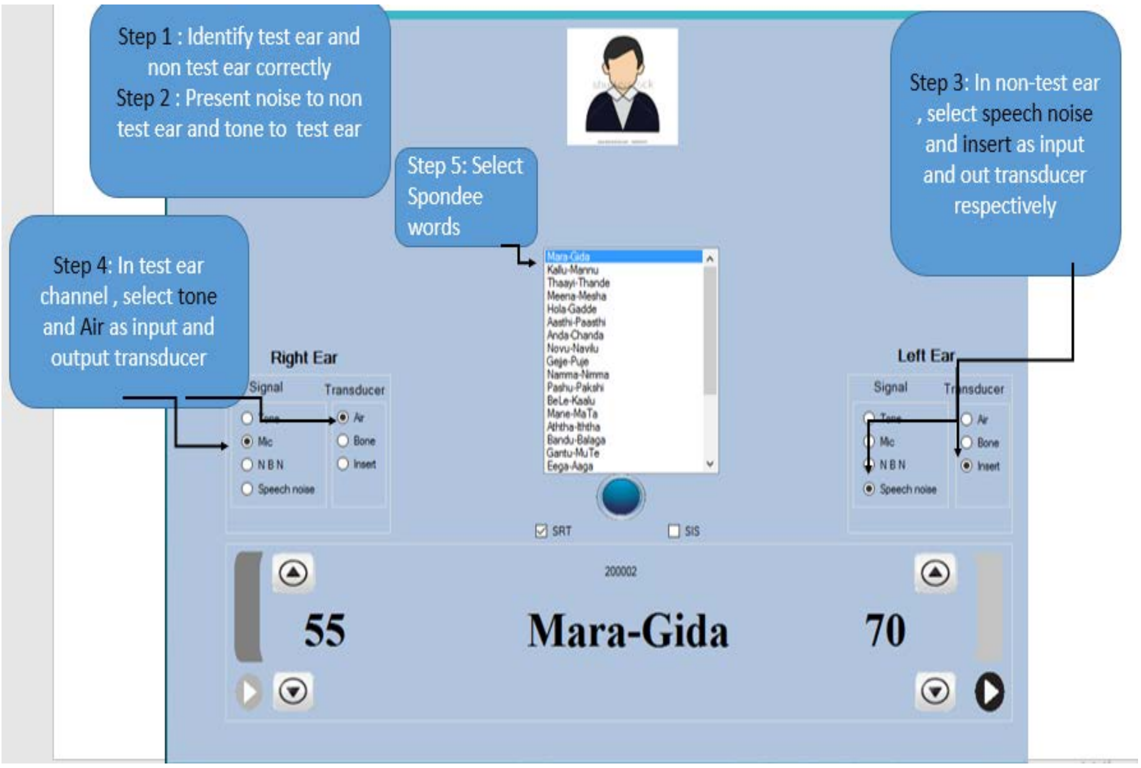



*Figure 2. 8. Represent SRT masking in speech audiometry module in the software.*

Figure 2.8 represents SIS masking in speech audiometry module in the software. For SIS, 25 PB words were loaded in the list, and the intensity dial was set at 40 dB SL (ref. SRT). The user randomly selects the word from the list to deliver it through the selected transducer. If masking is required, then the noise level calculated from the formula was set in the NTE, which is delivered through the insert receiver. Corresponding to the data point selected by the user, the response to the words was indicated by thumbs -up and -down. The user has to count the number of correct responses and convert it to percentage. This value is later related to the SRT stored in the database of the client selected. User is instructed to enter the value in percentage in the pop message soon after the test. If the value entered by the student matches the value in the database, then a message ‘correct' is shown.

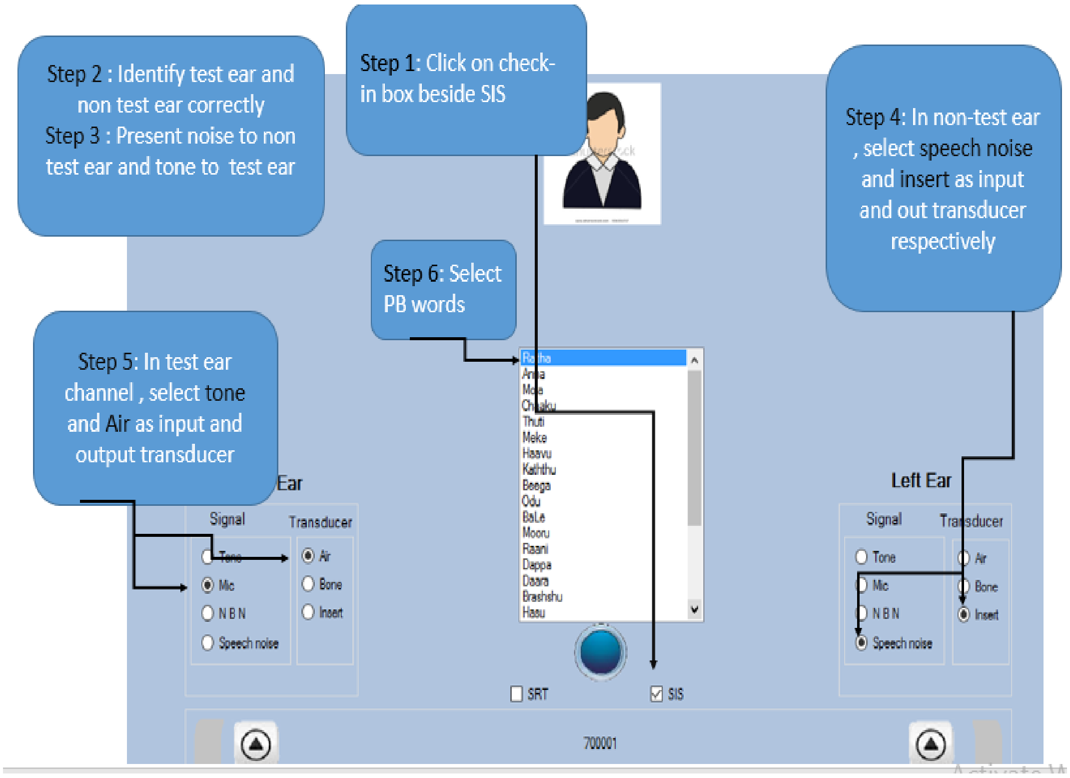



*Figure 2. 9. Represent SIS masking in speech audiometry module in the software.*

*Weber test.* The user should click on the checkbox of ‘Weber' test (Figure-2.9). From the transducer list, ‘bone' and from the signal list, ‘tone' has to be selected. For each frequency and intensity level, the response of lateralization was retrieved from the database.

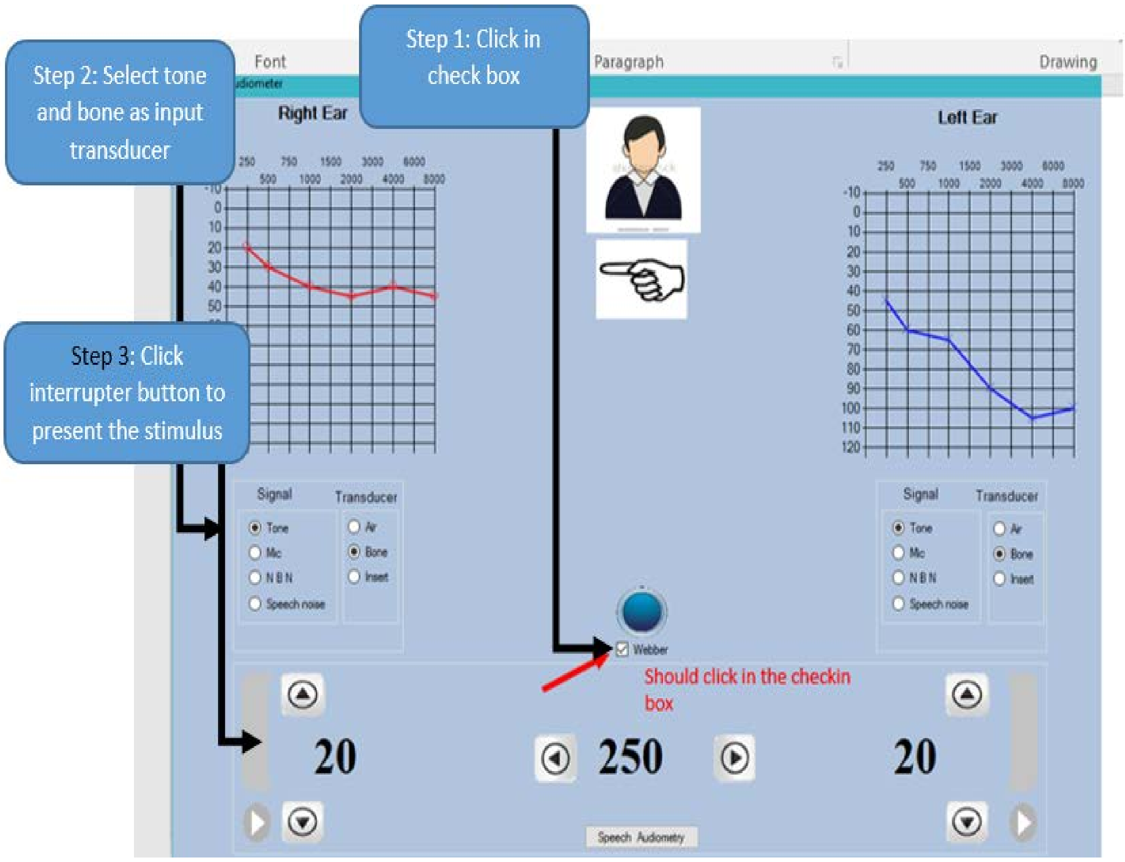



*Figure 2. 10. Represent weber in pure tone audiometry module in the software.*

**Phase II: Validation of developed software**

The developed software on simulation of the audiological profile was validated on second-year students.

**Participants.**

The developed software was validated on second-year B.ASLP students. A total of 15 second-year students were randomly selected, accounting to 25 % of the total strength of the class (60 students). These students were assessed quantitatively (MCQ examination and psychomotor skills) and qualitatively (Usability questionnaire). Pre- and post- tests comparative research design was incorporated in this phase of the study. Informed consent was obtained from each student. Ethical approval was obtained from institutional Ethical

Guidelines for Bio-Behavioural Research Involving Human Subjects of the All India Institute of speech and hearing. The details of quantitative and qualitative assessments are explained in subsequent sections.

### Quantitative assessment.

A. ***Knowledge Based Assessment.*** Clinical knowledge of the students was assessed by conducting a pre-test through multiple choice questions (MCQ) format.

Questions were prepared in MCQ format to assess student knowledge. Three faculty members from different Universities were requested to make two sets of 25 MCQs. The following instructions were given for the preparation of questions.

a) Questions should be framed on concepts of case history, otoscopic examination, hearing-related disorders, pure-tone audiometry, speech audiometry, and masking.

b) Questions based on the guidelines in the cognitive domain of 'Bloom's Taxonomy of Educational Objectives.' It comprises of five categories of questions, each tapping different cognitive domains. Cognition includes recall, comprehension, application, analysis, and other multiple abilities. The instruction under each category and a model paper were sent to the faculty (APPENDIX III).

c) The faculty were instructed to frame five questions from each category.

The questions framed in each category from all three faculty were collected. The question bank software (v-1) developed in the Department of Audiology was used to set the question papers. A total of 75 questions (3 examiners* 5 categories * 5 questions in each category) framed were uploaded to the software under the respective category. Three sets of 25 questions were set by the software in which five items in each group were randomly selected.

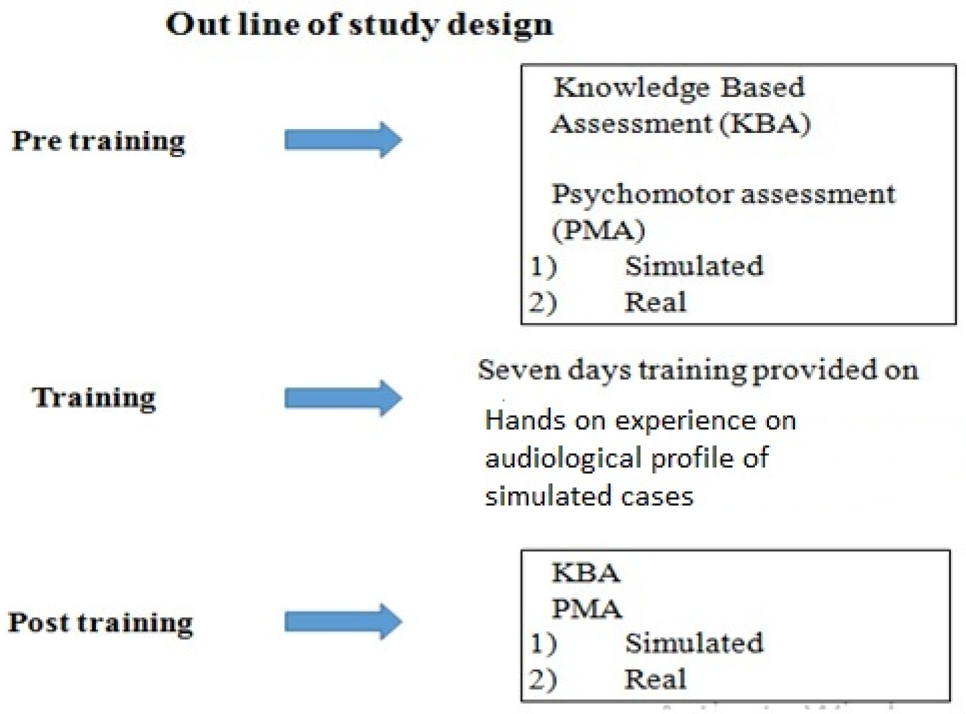
The algorithm in the software ensures none of the questions were repeated in each set. The research officer also verified this by visual inspection.

B**.** ***Evaluate psychomotor skills in audiological evaluation***. Student's psychomotor abilities in handling simulated and real cases were assessed using the summative approach. It included assessment checklists which are given in APPENDIX I. Checklist was used to assess the psychomotor skills on simulated cases. The marks against each skill are given. A mark ‘zero' was awarded if the student does the activity partly or incorrect. The total marks assigned to assess psychomotor skills for simulated cases was 35 and that for real cases was 20. For example, the student has to select the better ear using radio button displayed. If it is performed correctly, then the score of one mark is given for the skill ‘Selected appropriate ear for testing first’, or else, zero is given.

**Qualitative assessment.** Usability questionnaire developed by Heitz (2013) was adopted to assess the usefulness, ease of use, ease of learning, and satisfaction of the software. It comprised of 21 questions in four categories- eight questions in ‘usability,' seven questions in ‘ease of use,' four questions in ‘ease of learning,' and two questions in ‘satisfaction.' Each question was rated on a seven-point Likert rating scale, with ‘one’ being ‘strongly disagree’ and ‘seven’ being ‘strongly agree.' In scoring, each question rated in each of the categories was averaged.

**Procedure**

In the pre-test, psychomotor skills for real and simulated case were assessed. Also, the test was conducted in an objective format using multiple-choice questions to assess knowledge. Seven days of induction program on how to use the software was conducted. After training, knowledge was assessed using MCQs, psychomotor skills were evaluated for real and simulated cases, and the usability questionnaire was administered. Figure 2.10 represents the outline of the study design.




Note: KBA - knowledge-based assessment; PMA- psychomotor skill assessment

*Figure 2. 11 Outline of the study design*

***A.*** ***Pre-training:*** To validate the developed software, each student had to attend the testing in three visits. Each student was instructed to read on audiological findings of a variety of cases. This information was provided one week before their first visit. In the first visit, baseline assessment of knowledge and psychomotor skills on pure-tone and speech audiometry were assessed. An exam in MCQ format was conducted to assess knowledge. The duration of the test was 25 minutes. Before assessing psychomotor skills, an orientation was provided on how to use the software, which included a) selection of cases, b) uses of different key buttons and c) demonstration of handling the simulated case. The developed software was loaded on 15 computers, where the students were provided hands-on training. A simulated case on which masking criteria (AC, BC, SRT, and SIS) was applicable was considered. All students were instructed to carry out the audiological evaluation on that particular simulated case within thirty minutes. Five examiners were deputed for scoring psychomotor skills on simulated cases. Three students were assessed by each examiner (5 examiners *3 students). Further, in the audiology clinic, each student was given a real case where at least BC masking was required. This assessed the psychomotor skills on real patients.

***B.*** ***Training*****:** After two days of the first visit, the students of the study were asked to come for the second visit. In the first week of the training schedule, the students were encouraged to select the cases in simulated mode and visualize the audiological findings in them. Each session lasted for 45 minutes.

***C.*** ***Post training*****:** After two days of training, a knowledge base assessment was conducted by test in MCQ format. Also, psychomotor skills were assessed on another simulated case (masking criteria of BC, AC, SRT, and SIS) and a real case (with at least BC masking). The procedure to assess psychomotor skills is explained earlier. Further, each student answered the usability questionnaire to assess the perceived usefulness of the software.

# Chapter 3

## Results

The present study aimed to develop audiological evaluation training software and the validation of the developed software. The software for audiological evaluation was prepared and validated on 15B.ASLP students. The students were given training with the developed software and training effect was documented by comparison of pre- and post-training scores. Statistical analysis was performed using the SPSS for Windows (version 20). A Shapiro-Wilk test revealed that the data were normally distributed ($p > 0.05$). Hence, the data were analyzed using parametric tests. The following objectives were evaluated a) comparison of pre-training and post-training scores on knowledge of audiological skills b) comparison of before and after training psychomotor skills of handling simulated and real patients with hearing impairment c) Comparison of before- and after- training on parameters such as time taken to complete audiological evaluation of simulated case d) correlation of different components of usability questionnaire with scores of psychomotor skills in handling simulated patient and real patient f) Correlation of psychomotor skills between pre-training and benefit received from software in handing simulated and real patients and e) To predict benefit of psychomotor skills of audiological evaluation from score of pre-training psychomotor skills.

**Comparison of pre-training and post-training scores on knowledge of audiological skills**

Mean and standard deviation of pre- and post- training scores obtained from the knowledge based assessment (KBA) is provided in Figure 3.1. From the table, it is evident that post-training KBA scores are higher than pre-training KBA scores. A paired samples t-test revealed a significant [t (14) =10.37, p=0.001, $\eta^2_p$ = 8.9] higher post-training KBA score than pre-training KBA scores.

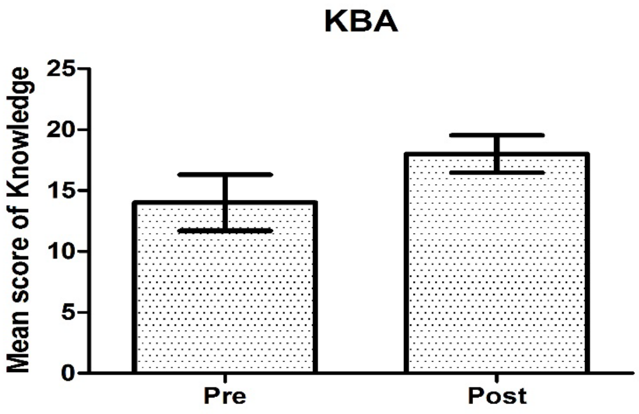
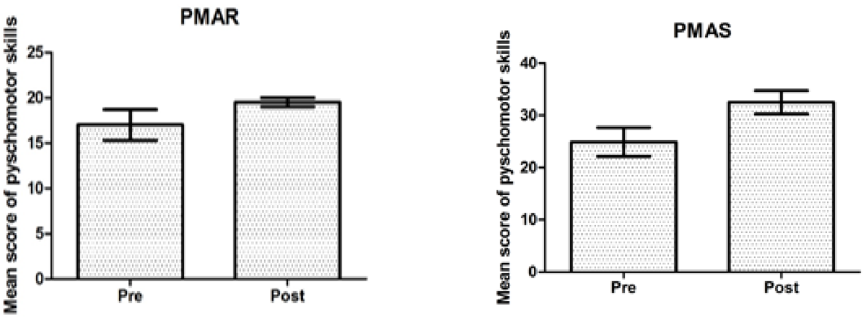



*Figure 3. 1: Mean scores of pre-training and post-training knowledge base assessment scores (KBA)*

**Comparison of psychomotor skills for before- and after- training in handling a simulated and real case**

Figure- 3.2. Provides the mean and standard deviation of pre- and post- training scores obtained from psychomotor skill assessment in simulated condition (PSAS) and real case (PSAR). A paired samples t-test revealed a significantly higher score obtained after post-training in handling simulated [t (14) =11.12, p=0.001, $\eta^2_p$ = 0.84] and real case [t (14) = 6.90, p=0.001, $\eta^2_p$ = 0.82] than in pre-training.




Note: PMAR denotes psychomotor skill assessment in the real case, and PMAS depicts psychomotor skill assessment in simulated case

*Figure 3. 2. Mean scores of pre and post training scores of psychomotor skills in real and simulated condition.*

**Comparison of before and after training on the time taken to complete audiological evaluation of the simulated hearing impaired case**

Figure-3.3. Provides the mean time taken to complete the audiological evaluation test in the simulated case. Paired sample t-test revealed that post-training mean time taken to complete evaluation was significantly less than pre-training. [t (14) = 14.51, p=0.001, $\eta^2_p$ = *8. 7*]

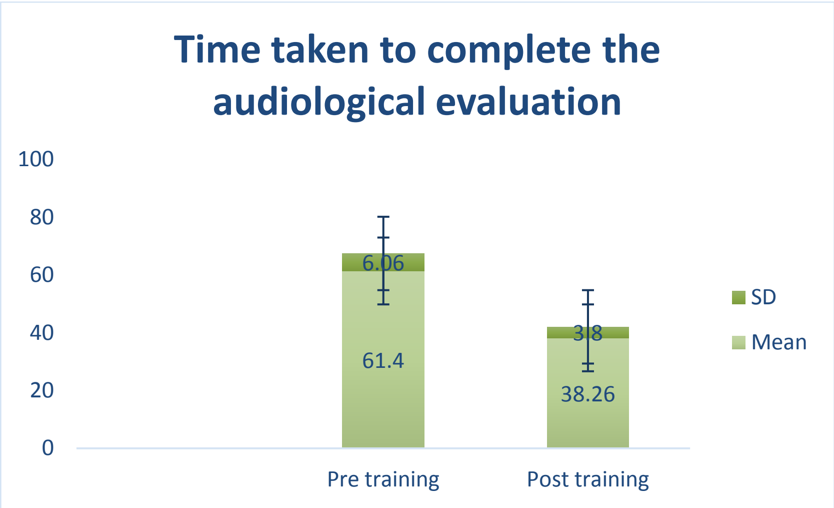



*Figure 3. 3: Mean and standard deviation of time taken to complete the audiological evaluation in pre-training and post-training conditions.*

**Correlation of different components of usability questionnaire (qualitative measure) with scores of psychomotor skills**

The benefit from training in the psychomotor skills of audiological evaluation in handling simulated case was obtained by subtracting the score of post-training psychomotor skills from pre-training score. Further, we correlated the benefit scores of psychomotor skills in handing simulated case with the components of the software usefulness questionnaire using the Pearson correlation coefficient. The results revealed that a moderate positive correlation between usefulness from software and benefit score of psychomotor skills in handing simulated cases (Table-3.1). We can infer that the high score in psychomotor skills of audiological evaluation is due to the training with the software (Figure 3.4).

*Table 3. 1. The r and p values of correlation between software usefulness and experience on audiological evaluation received in handling the simulated case.*

| **Usability questionnaire** | ***Simulated case*** | |
|---|---|---|
| | r-value | *p*-value |
| ***Usefulness*** | 0.53 | 0.041* |
| ***Ease of use*** | 0.32 | 0.235 |
| ***Ease of Learning*** | 0.08 | 0.754 |
| ***Satisfaction*** | 0.41 | 0.124 |

**Correlation is significant at 0.05*

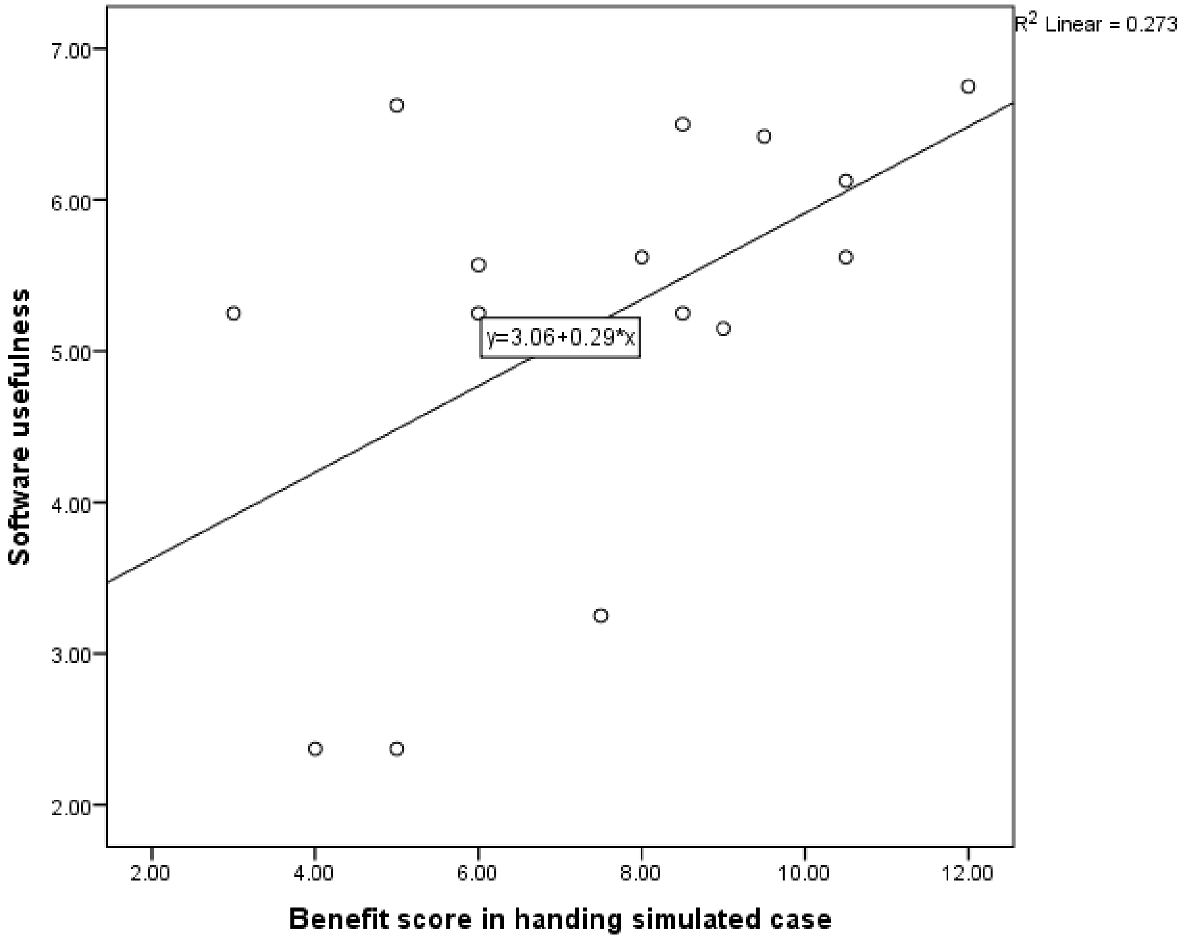



*Figure 3. 4: Scatter plot showing the relationship between the benefited score in handling simulated case and software usefulness.*

**Correlation of psychomotor skills between pre-training and benefit received from software in handing simulated and real case**

The results of the Pearson correlation revealed a strong negative correlation between pre-training and psychomotor skills and benefit received in psychomotor skills in handing simulated case [r=-0.70 N=15 p=0.05] and real case [r=-0.966, N=15 p=0.001]. We can conclude that the benefit of psychomotor skills received from software in handling either real or simulated case increased with low pre-training score of psychomotor skills.

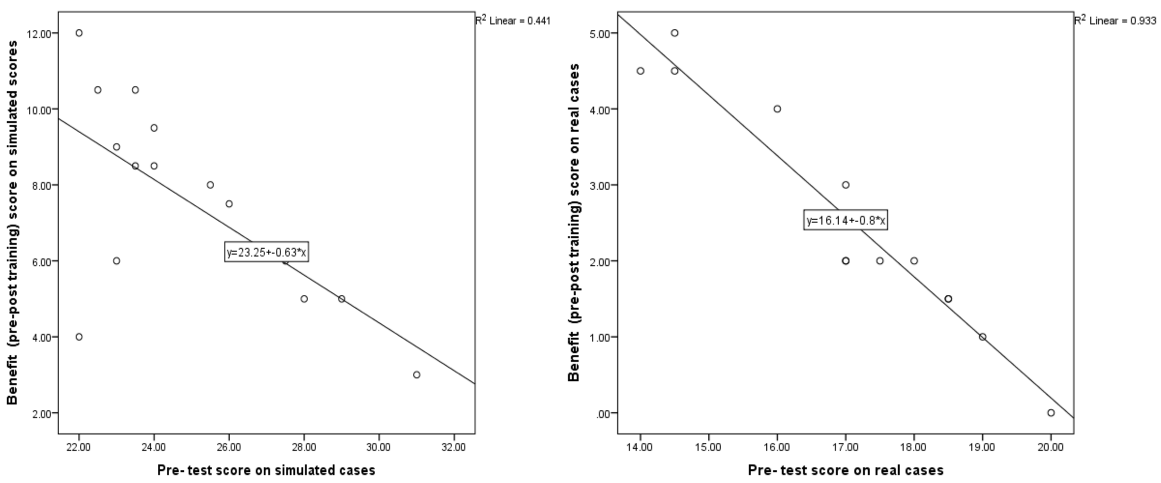



*Figure 3.5: Scatter plot showing the relationship between pre-test psychomotor score and benefit received from software in handing simulated and real case, respectively.*

**To predict the benefit of psychomotor skills of audiological evaluation from a score of pre-training psychomotor skills**

Further, a linear regression was performed to predict the benefit received from software in the psychomotor skills of audiological evaluation from the pre-training score of psychomotor skills in handling either simulated or real case. A model of regression was found significant in predicting benefit of psychomotor skills received in working out with the software from the pre-training score of psychomotor skills in handling simulated case [$R^2$=0.441, R =0.70 $F$ (1, 13) =10.26, $p$=0.007] and real case [$R^2$=0.933, R= 0.933, $F$ (1, 13) =180.79, $p$=0.001] (Figure 3.5). For simulated case, equation $y = a + b(x)$ ($a$ = 23.24; $b$ =-0.62) and for real case, equation $y = a + b(x)$ ($a$ = 16.14; $b$ =-0.79) were obtained to predict benefit received from software for the psychomotor skills to perform audiological evaluation, where y is the dependent variable, x is the independent variable, a is the intersection point of the curve and b is the slope of the curve. We can infer that benefit received, from software for the psychomotor skills to perform audiological evaluation is high if the pre-training psychomotor score is low and vice versa.

## Chapter 4

## Discussion

The study was conducted to develop and validate the software on audiological evaluation in the simulated mode. This was done with an intention to increase the knowledge and psychomotor skills necessary to conduct the pure-tone and speech audiometry accurately and effectively on patients within shorter durations.  Prior to the training, the students were instructed to prepare on pure-tone and speech audiometry to check their knowledge and psychomotor skills. It was observed that scores ranged from 11.84 to 16.56(out of 25) for knowledge base. The scores for psychomotor skills were 15.3 to 19.32 (out of 20) and 22.14 to 27.38 (out of 35). From this, it can be concluded that the students selected were homogenous.

The training effect was documented by comparing pre-training and post-training scores on knowledge and psychomotor skills on pure-tone and speech audiometry. A significantly higher score in post-training condition was observed than in pre-training condition on knowledge and psychomotor skills to handle real and simulated cases. This is because the novice students find it challenging to understand the concept of clinical masking in the field of audiology though they are taught in the classroom.

Most of the students reported that the pictorial representation of clinical masking in the software made them understand the concept better just using the formulae.

In the training session, the students practiced pure-tone and speech audiometry in the simulation mode. This enhances their logical thinking to arrive at the formula. It also helps reduce the cognitive load required to memorize the formula. When these students were asked to attend to cases in clinics, they seemed confident in asking the appropriate questions in the case history, utilizing the formulae to calculate appropriate masking level and looking into overall picture of the case by utilizing a battery of tests. This was also reflected in the time taken to complete the audiological evaluation. It was observed that after the experience of the audiological profile of different cases in simulated condition with the software, the students took lesser time to evaluate the actual patient.

The training on the audiological profile of different cases in a simulated mode made the students to experience the pattern of audiogram for various causes of hearing loss. They could correlate the findings of the different tests and interpret the results for final diagnosis. The feedback received when using the software allowed

them to rectify their error. A step by step instruction in the simulated software made them follow each of the tests accurately.

In the lab environment, students are well aware of the errors that are likely and ensure that they do not commit the same mistakes.

It provides a platform to redo the situation, record the response, and retrospect the approach during the activity, which gives feedback and aid in decision analyses. These are the benefits of the software, and proving that it has the edge over theory classes, clinical teaching or other lab environments.

The benefit score in psychomotor skills in handling the software was calculated by subtracting the post-training scores from the pre-training scores. The benefit received from the software in handling real and simulated cases was separately correlated with the usefulness of the software.  A moderate positive correlation was observed between the usefulness of software and the benefit score received in the psychomotor skills to handle both real and simulated cases. This is because software provided a safe environment to practice the necessary skills which they may encounter in real cases. The safe environment was ensured by a) appropriate masking level based on the patient's loss; b) reducing the chances of obtaining false threshold in individuals with neural adaptation, by presenting noise only during the presentation of the tone; c) message of error in the selection of the wrong ear for testing.

Our virtual clients were always available when students wished to practice. It allowed the students involved in this experiment to foster their clinical masking skills within a safe environment, with a measurable improvement when tested on the real case. Further, when the students are exposed to a wide range of simulated cases, they can choose to practice at their own pace. This gives each student the same opportunity for standardized training. Besides, the pop-up messages and feedback provided when they committed a mistake and rectifying the error overwhelm the students during training, from its constant presence or its richness in terms of information. Feedback offered in real-time allowed students the opportunity to correct their error in the simulation platform without committing the same mistake in real cases.

To sum up, using software has an advantage such as control over learning, saves time, and provided an option to correct the mistake quickly. Eventually, this prepares the student to handle clinical cases with ease.

Moreover, from the results, it is evident that those who scored poorly in pre-training assessment on knowledge and psychomotor skills have performed significantly higher after using the software. Conversely, the benefit from software on knowledge and psychomotor skills is less when a student had higher scores in the pre-training period which could be due to the ceiling effect as the scores in the pre-training condition is already high.

## Summary and Conclusions

Knowledge and psychomotor skills in pure-tone and speech audiometry increased after using the software. Also, novice students took less time to perform the audiological evaluation in real cases after using the software. Those novice students who had low scores on either knowledge or psychomotor skills on audiological evaluation improve in performance if they are trained with the developed simulated software.

## Limitation of the study

We have failed to document the maintenance effect to assess the retention of concept in students over the period. The benefit of the software is tested only on students of AIISH due to the convenience of data collection rather the multicentre study. The software instructs to rectify the errors committed by the student but fails to store it. If saved, then trainer/instructor can provide additional activities and or exercise to overcome the mistakes.

**Implications**

1. The software will allow students to experience and practice the necessary skills in handling frequent and rare cases.

2. The pictorial representation in the evaluation process, especially masking rules, facilitate the learning process and understanding the concepts logically rather than putting it in rote memory.

3. Repeated trials would allow students to accustom to handle the cases (frequent and rare) and rectify if a mistake is committed. Also, the software provides visual feedback on correct and wrong responses to facilitate learning.

4. A variety of case simulation brings clinical experience to the student at the laboratory environment itself.

5. The experience earned in performing structured/ programmed drills give confidence to the student and help to nature clinical reasoning.

6. All students do not have the same learning curve to understand the concept of clinical masking. This software allows students to use it at their own pace and learn effectively.

7. The feedback provides an opportunity to realize their mistake and try to rectify by themselves, basically engages in self-assessment.

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**APPENDIX I – Assessing the psychomotor skills of audiological evaluation.**

| | Sl No. | Basic audiological evaluation skills - Check-list | Marks allotted |
|---|---|---|---|
| A | **Otoscopy** | | |
| | 1 | Made correct observation on otoscopic examination. | 1 |
| B | **Case History** | | |
| | 1 | Recalled the components of case history before testing. | 1 |
| C | **Pure-tone audiometry** | | |
| | 1 | Selected appropriate ear for testing first. | 1 |
| | 2 | Selected the correct stimulus and transducer for air-conduction testing and bone-conduction testing. | 1 |
| | 3 | Correctly followed the bracketing procedure for threshold estimation. | 1 |
| | 4 | Obtained BC threshold in the ear lateralized on Weber test. | 1 |
| | 5 | Calculated the PTA for each ear correctly. | 1 |
| D | **Speech audiometry** | | |
| | 1 | Selected the input and output transducers for speech audiometry. | 1 |
| | 2 | Selected appropriate test material for SRT testing. | 1 |
| | 3 | Used correct presentation level to do the SRT testing. | 1 |
| | 4 | Used bracketing method to estimate SRT. | 1 |
| | 5 | Used appropriate test material to do SIS testing. | 1 |
| | 6 | Used SRT+40 or comfortable level minus 10 as the presentation level for obtaining SIS. | 1 |
| | 7 | Correctly estimated the SIS in percentage. | 1 |
| E | **Pure-tone BC Masking** | | |
| | 1 | Identified the frequencies in which BC masking is necessary. | 1 |
| | 2 | Selected correct input and output transducers for BC masking. | 1 |

| | | | |
|---|---|---|---|
| | 3 | Correctly presented the tone in the test ear and noise in the non-test ear. | 1 |
| | 4 | Calculated the BC minimum and BC maximum masking noise levels for frequencies that required masking. | 1 |
| | 5 | Correctly presented the initial masking noise through insert phone to the non-test ear and tone through BC vibrator to the test ear. | 1 |
| | 6 | Followed plateau procedure to identify the genuine BC threshold of the test ear. | 1 |
| | | **Subtotal A to E** | 20 |
| F | **Pure-tone AC masking** | | |
| | 1 | Identified the frequencies in which AC masking is necessary. | 1 |
| | 2 | Selected correct input and output transducers for AC masking. | 1 |
| | 3 | Correctly presented the tone in the test ear and noise in the non-test ear. | 1 |
| | 4 | Calculated the AC minimum and AC maximum masking noise levels for frequencies that required masking. | 1 |
| | 5 | Correctly presented the initial masking noise through insert phone/earphone to the non-test ear and tone through earphone to the test ear. | 1 |
| | 6 | The student followed the plateau procedure to identify the genuine AC threshold of the test ear. | 1 |
| G | **SRT masking** | | |
| | 1 | Identified the need for SRT masking. | 1 |
| | 2 | Selected the correct input and output transducers for SRT masking. | 1 |
| | 3 | Presented the speech in the test ear and noise in the non-test ear. | 1 |
| | 4 | Calculated the minimum and maximum masking noise level for SRT testing. | 1 |
| | 5 | Correctly presented the initial masking noise to non-test ear and speech to the test ear. | 1 |
| | 6 | Followed the plateau procedure to perform the SRT masking. | 1 |

| | | | |
|---|---|---|---|
| H | **SIS masking** | | |
| | 1 | Calculated the noise level to do SIS masking. | 1 |
| | 2 | Selected correct input and output transducers for SIS masking. | 1 |
| | 3 | Presented the speech in the test ear and noise the non-test ear. | 1 |
| | | **Subtotal F to H** | 15 |
| | | **Grand total (A to H)** | 35 |

**APPENDIX II: Instructions and pop-up messages for incorrect selection of keys in virtual audiometry**

| **Type of test** | **Instruction** | When to display the corrective pop-up message | **Pop up-messages for incorrect procedure** |
|---|---|---|---|
| AC testing | Which is the better ear | | **Correct selection**: Carry out AC testing for both ears using the bracketing method. Select appropriate transducer and stimulus<br>**Incorrect selection:** Please check the case history |
| Bracketing technique | | When the user is not following the correct procedure to obtain unmasked AC and BC threshold | Please follow the bracketing method |
| Weber test | At the set intensity, perform Weber test | | |
| BC masking | | When the user starts at different intensities of noise | Incorrect noise level, calculate minimum noise level |
| | | When the user starts at different intensities of tone. | Incorrect tone level, use unmasked BC of the test ear. |
| | | When the user starts at different noise and tone intensities. | Incorrect tone and minimum noise presentation level, use unmasked BC of test ear as tone intensity and calculate minimum noise level appropriately |

| | | | |
|---|---|---|---|
| AC masking | | When the user starts at different intensities of noise. | Incorrect noise level, calculate minimum noise level |
| | | When the user starts at different intensities of tone. | Incorrect tone level, use unmasked AC of the test ear |
| | | When the user starts at different noise and tone intensities. | Incorrect tone and minimum noise presentation level, use unmasked AC of test ear as tone intensity and calculate minimum noise level appropriately |
| Unmasked SRT masking | | When the user does not select the correct transducer | Please select appropriate input and output transducer |
| | | When the correct procedure is not followed for threshold estimation | Follow the bracketing method |
| Masked SRT | | When the user starts at different noise intensities. | Incorrect noise level, calculate minimum noise level |
| | | When user present spondee stimulus at a different intensity | Incorrect speech level, use unmasked SRT of test ear |
| | | When the user presents speech and noise at incorrect intensity levels | Follow the plateau procedure |
| Masked SIS | | When the user starts at different noise intensities. | Incorrect noise level |
| | | When the user presents PB word at different intensity | Incorrect speech level |

## APPENDIX III –Sample questions of each category which is used to assess knowledge on audiological evaluation

a) **Recall:** It is the least difficult question in the Blooms hierarchy, which requires knowledge on the concepts to answer.

To illustrate: Mid octave threshold measurement is recommended when thresholds between octaves differ by

A. < 15 dB

B. 15 dB

C. < 20 dB

D. > 20 dB

b) **Comprehension:** questions on comprehension are typically lengthy and to answer these kinds of questions, a student requires understanding and interpreting the information from the question.

To illustrate: A 17-year-old student presents with unilateral hearing impairment. Weber and Rinne testing of this patient supports conductive hearing loss. Otoscopic examination reveals a whitish patch behind tympanic membrane with attic perforation. Which of the following is the mostly likely diagnosis?

A. Cholesteatoma

B. Glomus tumour

C. Otosclerosis

D. Ossicular chain discontinuity

This question fits into comprehension category, since to answer, it demands comprehension of information present in the lengthy text in the question.

c) **Application:** Application based questions demands for the application of a particular diagnostic principle to arrive at the solution

To illustrate: Mention tuning fork Weber test results for the audiogram shown below.

A. Right

B. Left

C. Centre

This question falls into the analytical question category since the student has to apply the Stenger principle to answer this question.

d) **Analysis:** Analytical questions are the logical based question which requires the student to use logical thinking and reasoning ability.

To illustrate: Among the following options, identify the site of the lesion where the following audiological findings are most likely to occur

A. Retrocochlear pathology

B. Conductive

C. Cochlear

D. Neural

| | **Right ear** | **Left ear** |
|---|---|---|
| **PTA in dB HL** | 60 | 10 |
| **SIS in quiet** | 100% | 100% |
| **SIS in noise** | 100% | 100% |

This question belongs to the analytical category since it requires an analysis of the audiological data given in the table.

e) **Multiple cognitive abilities** This requires the use of more than one cognitive ability to answer the questions, these questions are the most difficult questions because it uses a combination of recall, comprehension, application and analytical questions.

To illustrate: If masked SRT is 85 dB HL, then calculate the optimum noise level (in dB HL) required to obtain masked speech identification scores.

A. 55

B. 65

C. 85

D. 75

This question falls under the Multiple cognitive categories, it requires to use recall and analytical skill to answer. Here, to calculate the masking noise level, the student has to recall the masking formula for the SIS masking, and she/he has to use the masked SRT to calculate noise level instead of unmasked SRT given in the audiogram**.**

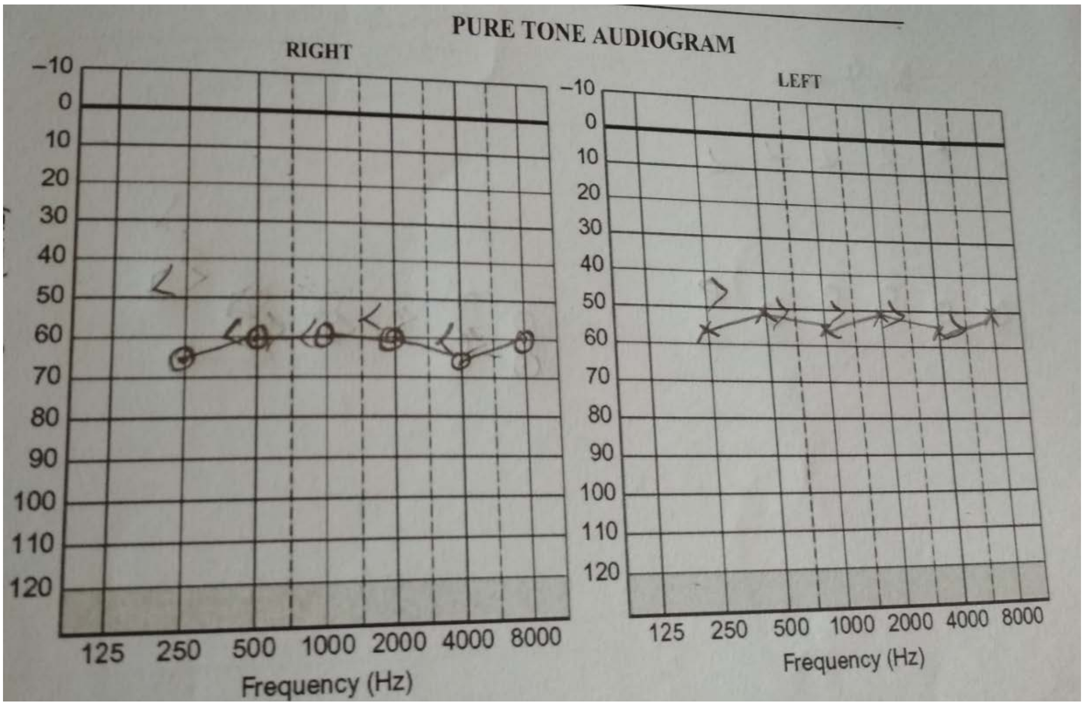
**Appendix –IV Question paper to assess the knowledge**

## <u>Set -1</u>

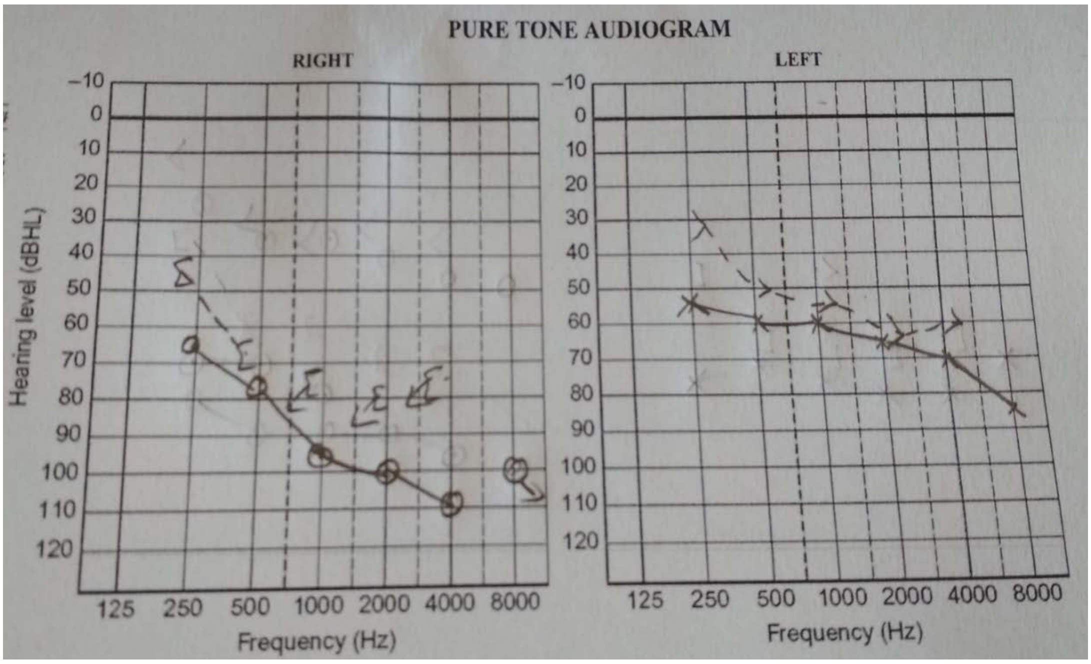
1) If the PTA of the right ear of a patient is 40 dB, then the SRT would be in the range of ………dB HL
   a. 30 to 50
   b. 50 to 60
   c. 20 to30
   d. 25 to 30
2) The right ear of a case is suspected to have a conductive hearing loss. The Rinne test finding in such an ear is
   a. The tuning fork sounds louder when it is held against mastoid versus when held near pinna
   b. no difference in loudness perception between two modalities
   c. the tuning fork sounds louder when it is held against pinna compared to when held against mastoid.

II. Mention tuning fork weber results for the following audiograms

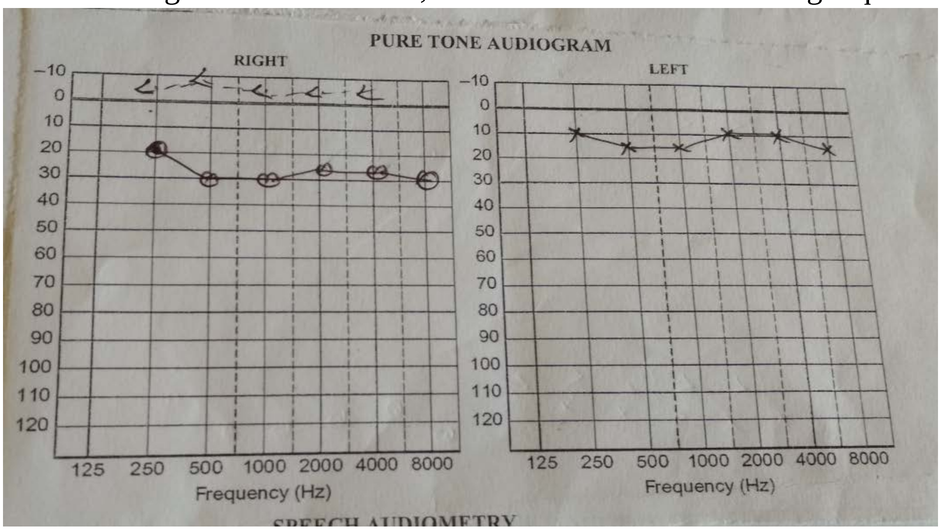
3)




4)




5) In the audiograms shown below, state whether reverse masking required or not




| Frequency | 250 | 500 | 1000 | 2000 |
|---|---|---|---|---|
| Weber test | Right | Right | Right | Right |

6) According to modified Hughson-Westlake procedure, if the listener does not respond or shows negative response for a 1 kHz tone at 30 dB HL, then the
   a. intensity is increased in 10 dB step size until the listener gives a positive response
   b. intensity is increased in 20 dB step size until the listener gives a positive response
   c. intensity is decreased in 5 dB step size until the listener gives a positive response
   d. intensity is decreased in 10 dB step size until the listener gives a negative response
7) Paracusis Willis phenomenon is seen in
   a. cochlear hearing loss
   b. conductive hearing loss
   c. retro cochlear and mixed hearing loss
   d. central auditory processing disorder

8) Low frequency maskers are better maskers compared to high frequency maskers because of
   a. Upward spread of masking
   b. Downward spread of masking
   c. Remote masking
   d. Central masking
9) Rising configuration audiogram with sensorineural hearing loss is likely to occur in
   a. otitis media
   b. Meniere's Disease
   c. semicircular canal dehiscence
   d. cochlear otosclerosis
10) Extended high frequency audiometry is indicated in …….. condition.
   a. Meniere's disease
   b. perilymphatic fistula
   c. ototoxicity
   d. Otosclerosis
11) Which of the following findings of PTA and SIS in noise are predictive of ANSD?
   a. PTA = 30 dB, SIS = 100%
   b. PTA = 30 dB, SIS = 90%
   c. PTA = 30 dB, SIS = 20%
   d. PTA = 30 dB, SIS = 80%
12) Minimum effective masking level for SIS masking depends on
   a. masked SRT, largest $ABG_{NTE}$
   b. unmasked SRT, largest $ABG_{NTE}$
   c. unmasked SRT, least $ABG_{TE}$
   d. masked SRT, least $ABG_{NTE}$
13) Which of the following findings is NOT likely to occur in otosclerosis?
   a. Presence of Schwartz's sign in tympanic membrane
   b. Presence of Carhart's notch in the audiogram
   c. males are likely to affected than females
   d. Presence of conductive or mixed hearing loss
14) Efficiency of masker depends on
   a. over all energy of masking noise
   b. frequency distribution of masking noise
   c. overall energy as well as frequency distribution of masking noise
   d. none of the above

15) The most effective type of noise for speech masking
   a. Broad band noise
   b. White noise
   c. Pink noise
   d. Speech shaped noise
16) A 64-year-old patient presented with the complaint of reduced hearing sensitivity in both ears and difficulty in understanding speech in the presence of background noise. Otoscopic evaluation revealed normal tympanic membrane in both ears. No other

otological complaints were reported. Audiological findings report bilateral sloping moderate sensorineural hearing loss. Identify most probable cause of hearing loss

a. Menieres disease
b. Presbycusis
c. Otosclerosis
d. Ototoxicity

17) A 17 year old student presents with unilateral hearing impairment. Weber and rinne testing of this patient supports conductive hearing loss. Otoscopic examination reveals a whitish patch opposing polyp situated behind a normal appearing tympanic membrane. Which of the following is the mostly likely diagnosis?

a. Cholesteatoma
b. Glomous jugular tumour
c. Otosclerosis
d. Ossicular chain discontinuity

18) A 40-year-old female reported to an audiology clinic with the complaint of the reduced hearing loss in both ears. Audiological findings reports a pure tone average of 90 dB in both ears and speech recognition threshold of 30 dB. Identify the most probable cause of hearing loss

a. CSOM
b. Otoscelrosis
c. Functional hearing loss
d. Presbycusis

19) A 55-year-old male was subjected for audiological evaluation, patient history revealed exposure to high intensity sounds in work place for more than 8 hours per day. Patient reports sleep disturbance due to ringing sensation in both ears. Audiogram revealed 4kHz notch in AC. Identify the probable cause of hearing loss.

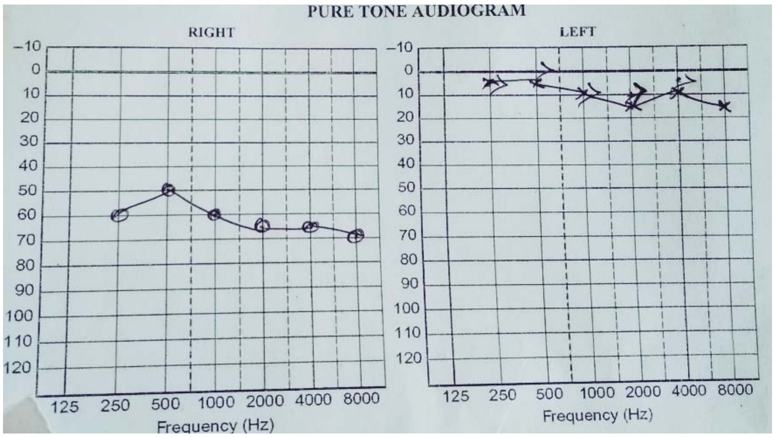
a. Otosclerosis
b. Menieres
c. NIHL
d. CSOM

20) A 40- year- old female patient came to clinic and presented a complaint right ear is better than left ear. It was found that masking was necessary where right ear threshold was relatively better than left ear by 20 dB. What kind of masking is necessary with the difference in threshold between ears posed by client and in which ear tone and noise will be presented?

a) BC in right ear and noise in left ear
b) AC in left ear and noise in right ear
c) BC in left ear and noise in right ear
d) AC in right ear and noise in left ear

III. Answer the following questions from the available Audiological findings

a)

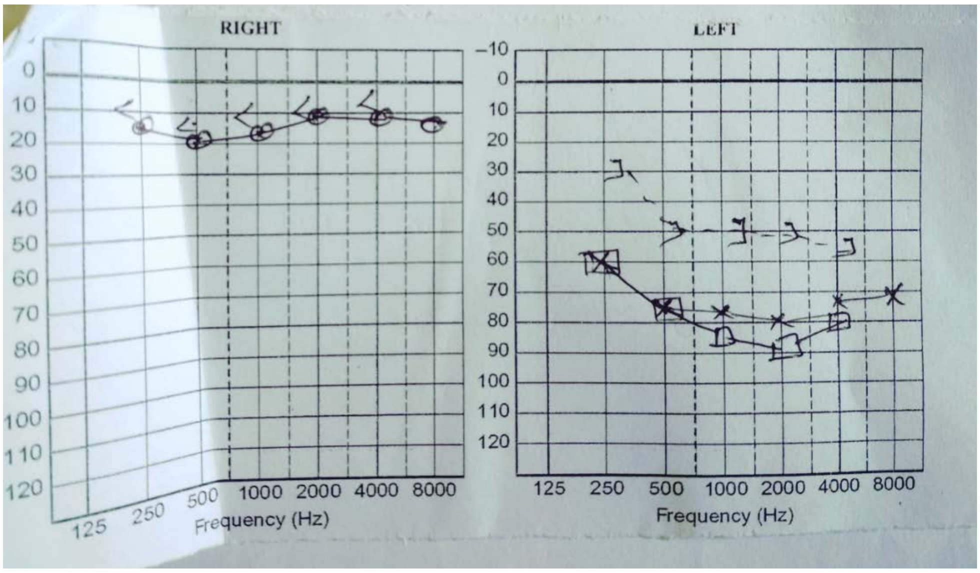



| Frqs → Weber test | 250 Hz | 500 Hz | 1000 Hz | 2000 Hz |
|---|---|---|---|---|
| | L | L | L | L |

21) Calculate minimum masking noise level to obtain masked BC threshold at 500Hz
   a. 50 dB   b. 45 dB   c. 40 dB   d. 55 dB

22) If right ears masked BC threshold for 1kHz is 15dBHL, then calculate maximum masking noise level.
   a. 70 dB   b. 55 dB   c. 80 dB   d. 75 dB

23) Wat is the occlusion effect correction factor need to be added at 500 Hz if the $ABG_{NTE}$ is less than 20 dB?
   a. 5 dB   b. 10 dB   c. 15 dB   d. 0 dB




| | SRT | SIS |
|---|---|---|
| Right ear | 15 | 100% |
| Left ear | 70 | 88% |

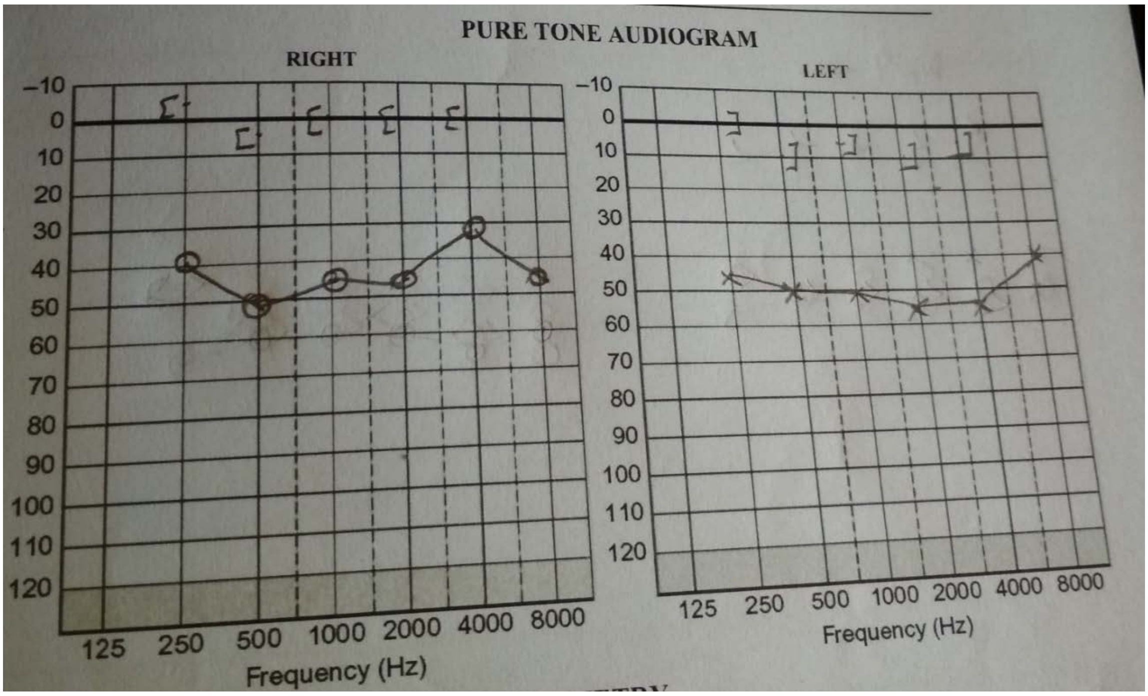
24) Calculate minimum noise level required to obtain masked speech recognition threshold
    a. 55 dB b. 70 dB c. 30 dB d. 80 dB

25) If masked SRT is 85 dBHL, then calculate the optimum noise level required to obtain masked speech identification scores.
    a. 65 dB b. 40 dB c. 50 dB d. 70 dB

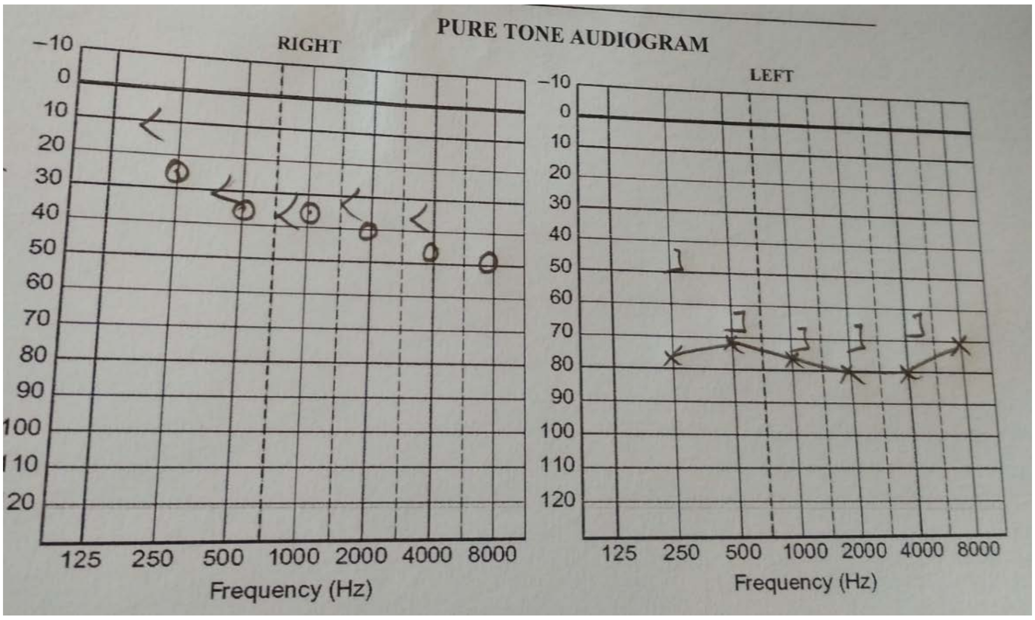
Set -2

1. Mid-octave threshold measurements are recommended when thresholds between octaves differ by
   a. < 30 dB
   b. > 20 dB
   c. < 20 dB
   d. > 30 dB
2. During pure-tone threshold assessment, the rule followed is
   a. 5 down/ 10 up
   b. 15 down / 10 up
   c. 10 down/ 5 up
   d. 15 up/ 10 down
3. Nauton’s dilema is a condition where
   a. maximum noise level is greater than audiometric intensity limits
   b. minimum masking noise level is greater than maximum masking noise levels.
   c. masking criteria is not satisfied
   d. maximum masking noise level is greater than minimum masking noise level
4. In plateau procedure, if the threshold shift is in accordance with increase in noise level, then it suggests
   a. under masking
   b. over masking
   c. effective masking
   d. Inadequate masking
5. SRT –PTA disagreement is seen in ……. Hearing loss
   a. Conductive hearing loss
   b. Mixed hearing loss
   c. Functional hearing loss
   d. Cochlear hearing loss
6. In Hood’s masking procedure, if the threshold of test ear is increased with application of masking noise in the non-test ear, then
   a. intensity of noise should be increased by 5 dB
   b. intensity of tone should be increased by 5 dB
   c. intensity of noise should be decreased by 5 dB
   d. intensity of tone should be decreased by 5 dB
7. Among the following stimuli, which stimulus has better masking efficiency to mask 1kHz pure tone
   a. 1 kHz pure tone
   b. 2 kHz pure tone
   c. 1 kHz narrow band noise
   d. 0.5 Hz narrow band noise

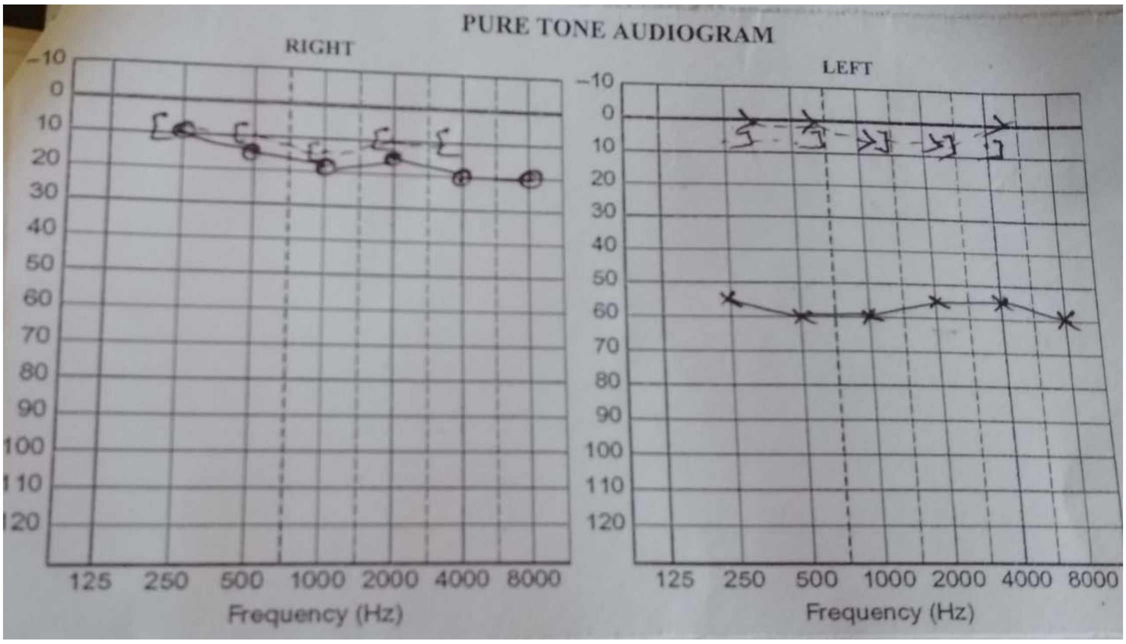
8. *Mention tuning fork weber results for the following audiograms*




a. Right b. Center c. left d. unable to make out

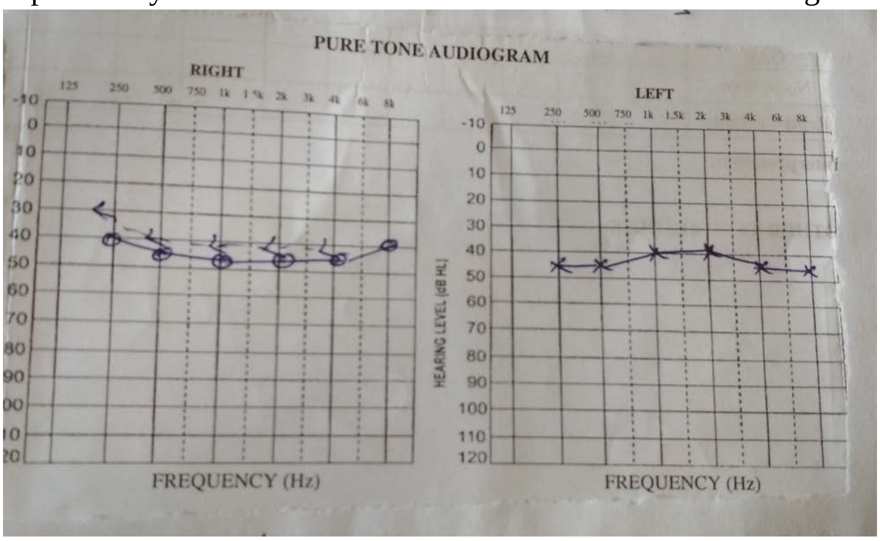



9. Calculate the PTA in the left ear




a. 62.5 dB b. 70 dB c. 70 dB d. 60 dB

10. The possibility of lateralization in weber test for the below audiogram



a. Cannot make out b. center c. right d. Left

11. Following are signs and Audiological findings of glomus jugular tumor EXCEPT
    a. Pulsating tinnitus
    b. Presence of hoarse voice
    c. Schwartz sign
    d. Rising sun sign
12. Cross hearing depends on the amount of cross over and ……
    a. AC threshold of test ear
    b. BC threshold of test ear
    c. Ac threshold of non-test ear
    d. BC threshold of non-test ear

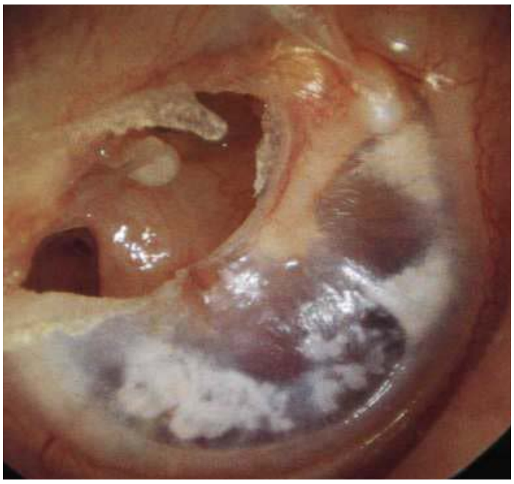
13. Identify the site of lesion from the below audiological findings are most likely to occur.

| | **Right ear** | **Left ear** |
|---|---|---|
| **PTA** | 60 | 10 |
| **SIS in quiet** | 100% | 100% |
| **SIS in noise** | 100% | 100% |

    a. Cochlear pathology
    b. Conductive pathology
    c. Neural pathology
    d. Retro cochlear pathology

14. In which of the following condition over masking takes place
    a. $AC_{NTE}$- IA > $BC_{TE}$
    b. $AC_{TE}$-IA > $BC_{NTE}$
    c. $BC_{NTE}$- $AC_{NTE}$ > IA
    d. $BC_{TE}$-$AC_{NTE}$ > IA

15. The parent of 4-year child reports to an audiologist with following complaints: History of recurrent ear discharge which is yellowish in color, ear pain, and frequent attacks of cold. Identify the most probable cause for rapture of TM.



a. CSOM
b. Otosclerosis
**c.** Cholesteatoma
d. ET tube dysfunction

16. A 5-year-old boy was brought to an audiology clinic with the complaint of external ear deformity. ENT report reveals right ear atresia. The Weber tunning fork test revealed lateralization to right ear. What type of hearing loss can be expected in client.

a. Sensorineural hearing loss
b. Normal hearing
c. Conductive pathology
d. Mixed hearing loss

17. A 50 year old client presented complaint of hearing loss and blocking sensation in both ear. Unmasked pure tone testing results revealed a minimal hearing loss in left ear and right ear mild conductive hearing loss. What are the below transducers options can be used to identify the genuine threshold for the above audiometry profile?
a) BC in right ear and insert in left ear
b) Inserts in right ear and BC in left ear
c) BC in right ear and earphone in left
d) A and C

18. A 39 years old man consulted an audiologist for complaint of difficulty in understand speech. Otoscopic evaluation revealed bilateral intact tympanic membrane and audiological reports revealed the following findings; Irregular configuration, inconsistent responses and poor speech identification scores in noise

| | **Right ear** | **Left ear** |
|---|---|---|
| **PTA** | 60 | 58.65 |
| **SIS in quiet** | 76% | 80% |
| **SIS in noise** | 48% | 56% |

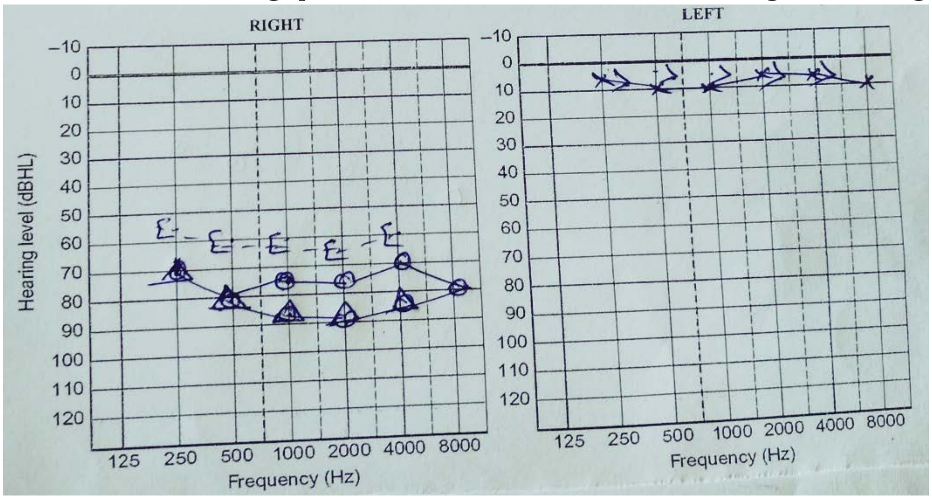
g the following options, identify the site of lesion where above Audiological findings are most likely to occur.

a. Retro cochlear pathology
b. Cochlear pathology
c. Conductive pathology
d. Mixed pathology

19. Audiometry testing was performed on a twenty-year-old patient. In 500 Hz frequency, right BC threshold is 25 dB and left ear AC thresholds in insert is 80 dB. In such condition how much cross over can occur?

a) 40
b) 10
c) 55
d) 25

Answer the following questions from the available Audiological findings

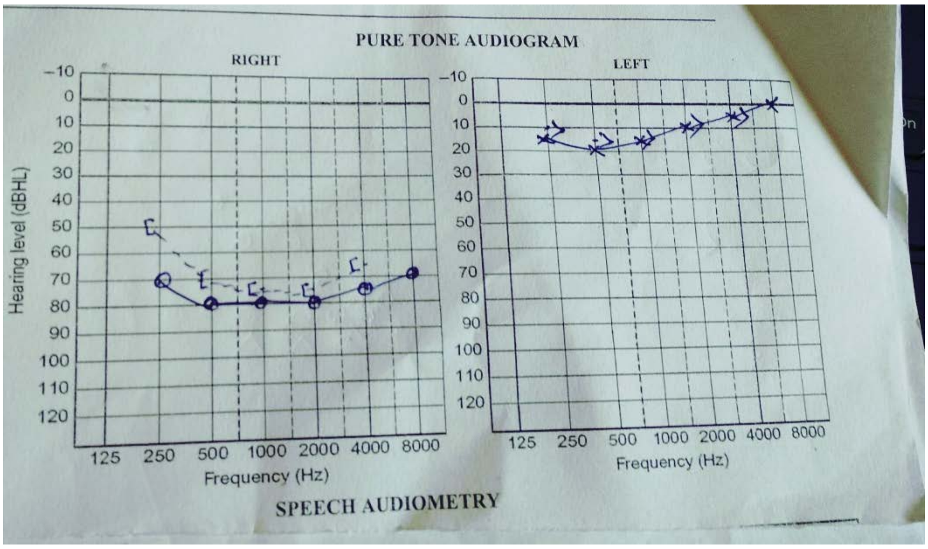



| Frqs → | 250 Hz | 500 Hz | 1000 Hz | 2000 Hz |
|---|---|---|---|---|
| Weber test | C | L | L | L |

| | Unmasked | Masked SRT | Unmasked SIS |
|---|---|---|---|
| Right | 75dbHL | 80dBHL | 76% |
| Left | 15dBHL | - | 100% |

20. Optimum masking noise level required to obtain masked SIS
i. 60 dB HL
ii. 55 dB HL
iii. 50 dB HL
iv. 65 dB HL

21. Calculate minimum masking noise level required to obtain AC masked threshold for 4kHz.

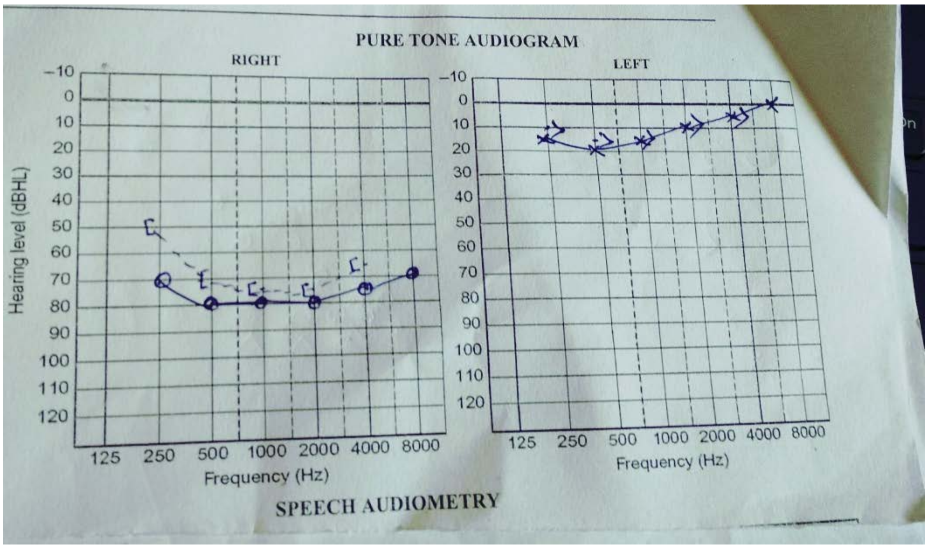



| Frqs → | 250 Hz | 500 Hz | 1000 Hz | 2000 Hz |
|---|---|---|---|---|
| Weber test | C | R | R | R |

a. 40 dB b. 50 dB c. 60 dB d. 45 dB

22. ……….. masking are/ is required
   i) BC, SIS and SRT
   ii) BC and AC
   iii) BC , AC, SRT and SIS
   iv) BC

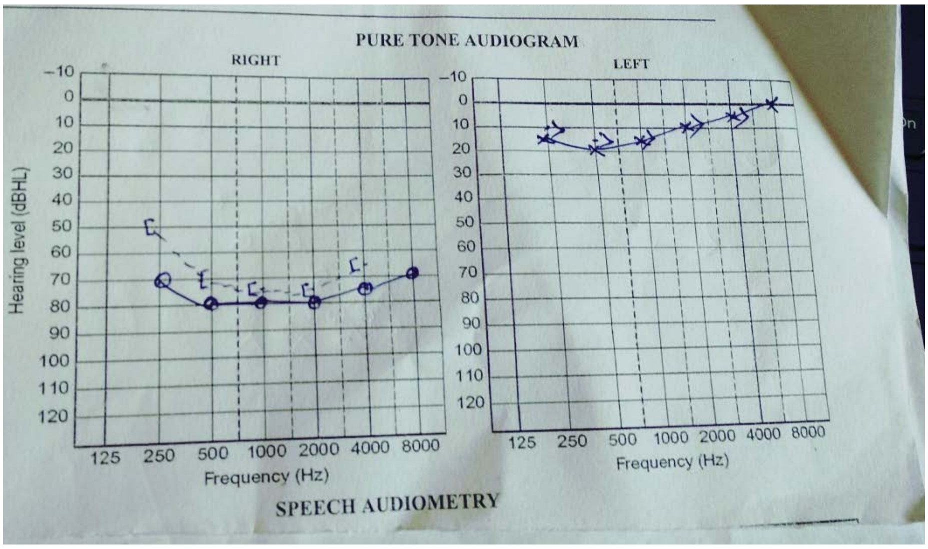
23. Calculate the minimum noise level for BC masking of a pure tone of 2kHz.




a. 20 dB b. 40 dB c. 60 dB d. 45 dB

24. Following are the Audiological findings of auditory neuropathy spectrum disorder EXCEPT
    a. Irregular pattern of audiogram
    b. Peaked pattern of audiogram
    c. Poor speech identification scores
    d. Good speech identification scores

25. How much dB of tone at 1kHz in right ear is cross over to the left ear?




a. 40 dB

b. 20 dB

c 80 dB

d. 5 dB

## Set -3

1) According to ASHA guidelines, threshold estimationshould start from 1 kHz frequency. It is because there is
    a) better test retest reliability at 1 kHz
    b) better hearing sensitivity at 1 kHz
    c) 1 kHz frequency is mid frequency between 250 0.25 and 8 kHz
    d) Both a) and b)

2) The SIS scores would be better in …………………. degree & ……. type of hearing loss.
    a) moderate; conductive
    b) moderate; SNHL
    c) moderate; mixed
    d) moderately severe, mixed

3) Extended high frequency audiometry is indicated in …….. condition.
    a) Meniere's disease
    b) perilymphatic fistula
    c) ototoxicity
    d) Otosclerosis

4) Tullio's phenomenon is seen in ……. condition
    a. Meniere's disease
    b. perilymphatic fistula
    c. ototoxicity
    d. otosclerosis

5) Following are the audiological findings of noise induced hearing loss EXCEPT
    a) Presence of 3 kHz notch in both AC and BC thresholds
    b) Presence of 4 kHz notch in both AC and BC thresholds
    c) Presence of 2 kHz notch only in AC threshold
    d) Presence of 3 kHz notch in both AC and BC thresholds

6) Following are the audiological findings of auditory neuropathy spectrum disorder EXCEPT
    a) Irregular pattern of audiogram

b) Peaked pattern of audiogram
c) Poor speech identification scores
d) Good speech identification scores

7) Decision about requirement of masking does not depend on
a) Air-conduction threshold of test ear
b) Air-conduction thresholds of non-test ear
c) Bone-conduction threshold of test ear
d) Bone-conduction threshold of non- test ear

8) Cross hearing occurs when
a) $PL_{TE}$-IA < $BC_{TE}$
b) $PL_{TE}$-IA > $BC_{TE}$
c) $PL_{NTE}$-IA > $BC_{NTE}$
d) $PL_{NTE}$-IA< $BC_{NTE}$

9) In Hood's masking procedure, if the threshold of test ear is increased with application of masking noise in the non-test ear, then
a) intensity of noise should be increased by 5 dB
b) intensity of tone should be increased by 5 dB
c) intensity of noise should be decreased by 5 dB
d) intensity of tone should be decreased by 5 dB

10) Factors affecting minimum effective masking level for air-conduction are:
a) $AC_{TE,}$ IA, and $ABG_{TE}$
b) $AC_{TE,}$ IA, and $ABG_{NTE}$
c) $AC_{TE,}$ IA, and OE
d) $AC_{TE,}$ IA , OE, and $ABG_{TE}$

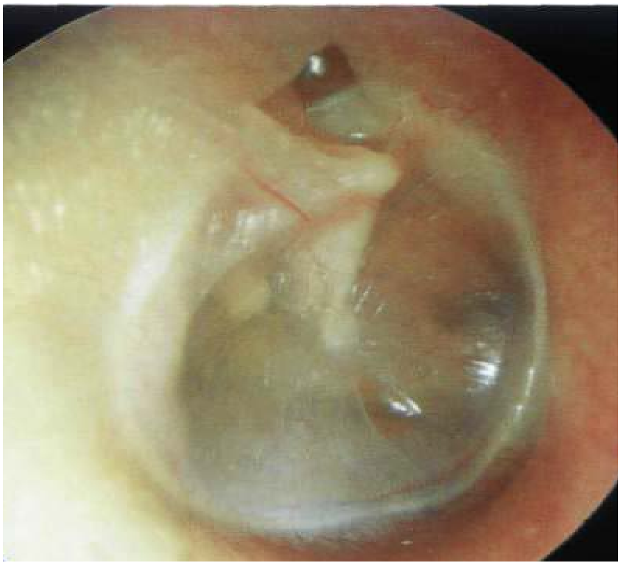
11) Which among the following stimuli is better masker to mask 1 kHz pure tone
a) 0.5 Hz NBN
b) 2 kHz NBN
c) 4 kHz NBN
d) 3 kHz NBN

12) Masker is said to be better
a) if it requires higher intensity to mask the maskee
b) if it requires lower intensity to mask the maskee

c) if masking factor is less
d) If masking factor is more

13) Mastoid placement of bone vibrator is preferred over forehead placement because
a) it has lowest dynamic range region
b) mastoid placement requires less energy to reach the threshold
c) mastoid placement requires more energy to reach the threshold
d) mastoid placement has 0 dB IA at higher frequencies.

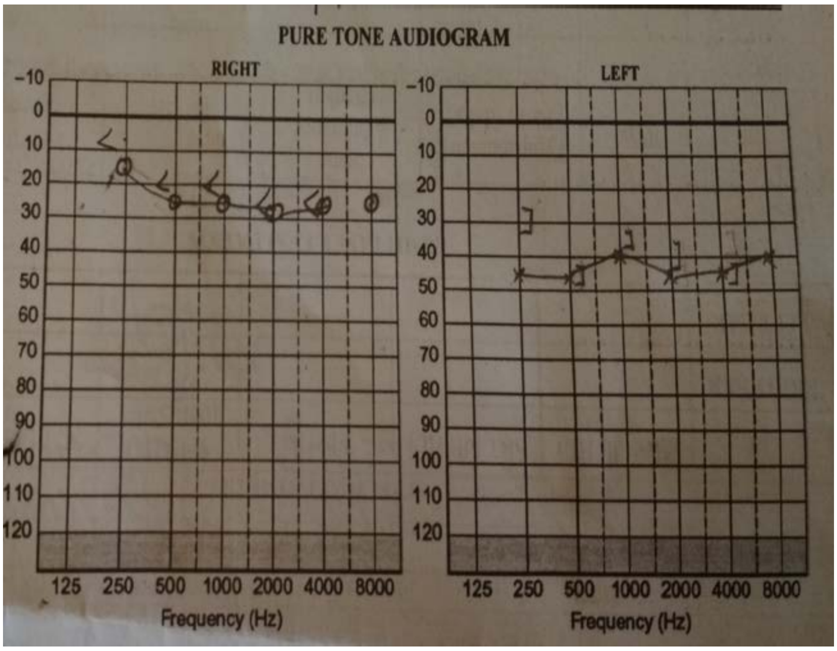
14) A 9 year-old child was brought to an audiological clinic with a complaint of recurrent ear discharge since past four months in the right ear. No other otological complaints were reported. Otoscopic examination revealed epitympanic retraction pockets. Identify probable cause and type of hearing loss.



1) A 45 year-old male reported to an audiologic clinic post chemotherapy for audiological evaluation. Otoscopic evaluation revealed bilateral intact tympanic membranes. Identify probable cause and type of hearing loss.

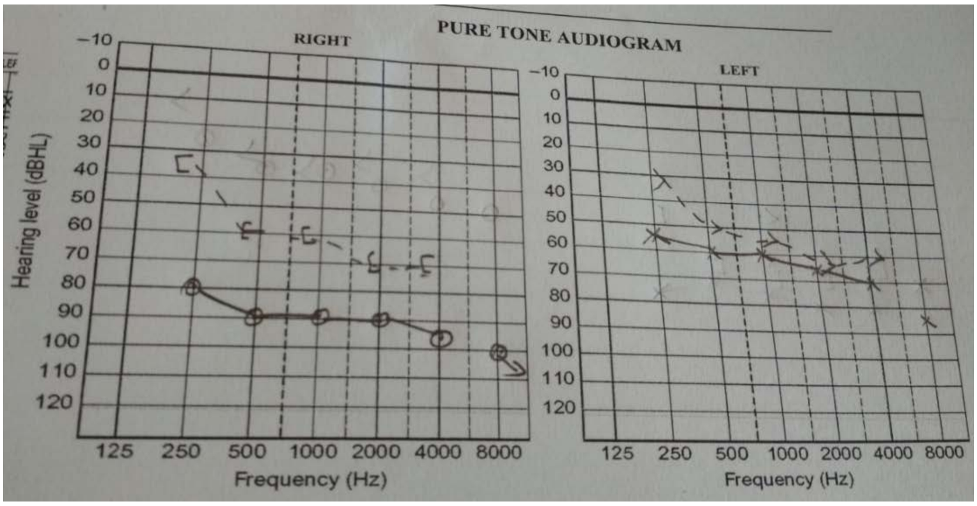
2) A 45 year-old female reported to an audiologic clinic with a complaint of frequent episodes of vertigo since past six months, which lasts for a few minutes to hours. She reported symptoms of aural fullness, low pitch tinnitus, and hearing loss in left ear. She also stated that these symptoms were fluctuating in nature. On otoscopic evaluation, intact tympanic membrane in both ears was revealed. Identify probable cause and type of hearing loss

I5. Mention Weber lateralization results for the following audiograms




a) Right
b) Left
c) Center

16. Mention Weber lateralization results for the following audiograms




a) Right
b) Left
c) Centre

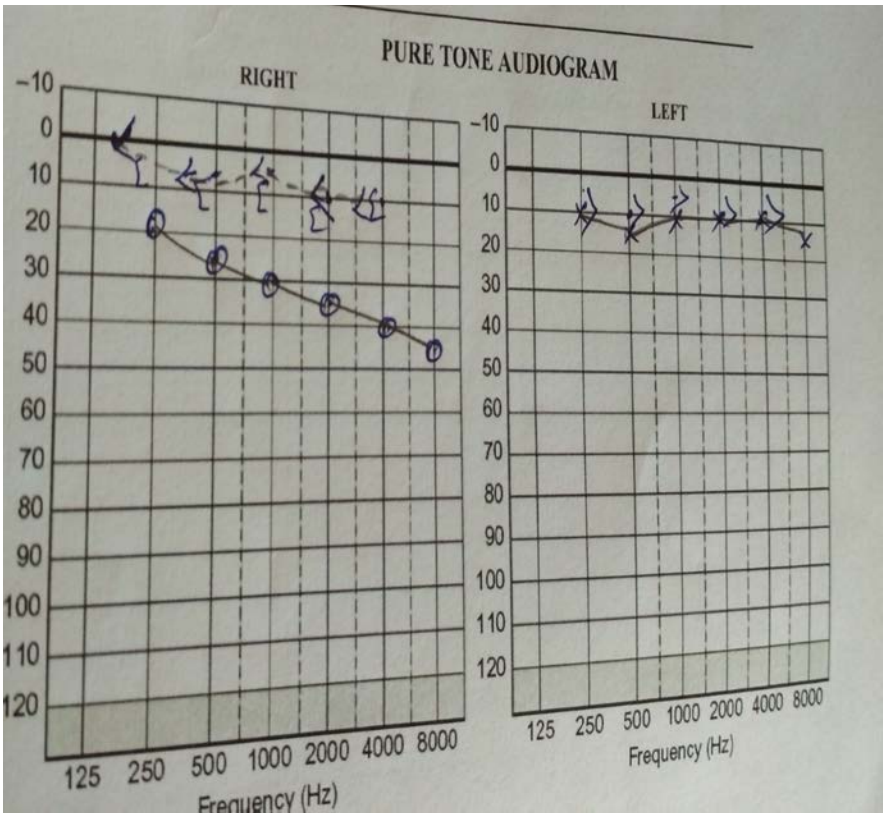
17. In case history if the patient blocking sensation in left ear, what would be the type of hearing loss be predicted

a. SNHL b. Mixed hearing loss c. conductive hearing loss

18. Mass tilt in the audiogram is seen in which cause of hearing loss

a. otitis media d. otosclerosis c. ossicular discontinuity c. a and c

19. From the below given audiological findings, answer the following questions




| Freqs→ | 250 Hz | 500 Hz | 1000 Hz | 2000 Hz |
|---|---|---|---|---|
| Weber test | C | R | R | C |

a) Is reverse masking required?
   1) Yes
   2) No
b) Maskee is presented in …… ear and noise presented in …… ear
   1) right ear, left ear

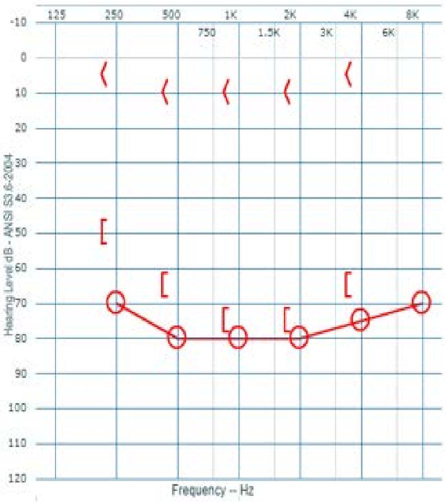
2) left ear, right ear
3) right, right
4) left, left

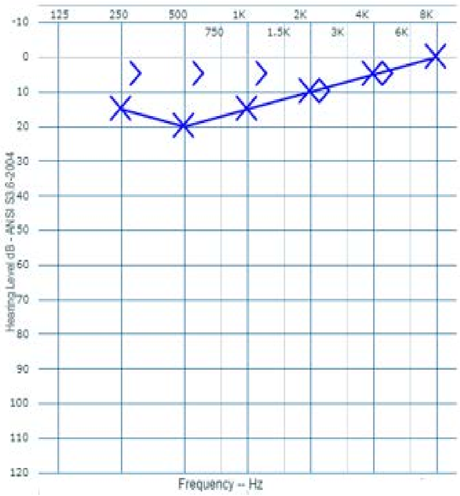
c) Calculate minimum reverse masking level for a 2 kHz pure tone:

d) Is AC masking required for 500 Hz? If yes, calculate minimum masking level.

e) Maximum masking level for a pure tone of 1 kHz AC and SRT masking are ……… and ……..dBHL
1) 75 and 65
2) 65 and 70
3) 75 and 75
4) 65 and 65

20. From the below given audiological findings, answer the following questions




| Freqs→ | 250 Hz | 500 Hz | 1000 Hz | 2000 Hz |
|---|---|---|---|---|
| Weber test | C | L | L | L |

| | SRT | SIS |
|---|---|---|
| **Right ear** | 75 dB HL | 76% |
| **Left ear** | 15 dB HL | 92% |

a) ………. masking is required in …… ear
1) BC and SRT; right

2) BC and AC; right
3) BC, AC; SRT, and SIS; left
4) BC, AC, SRT, and SIS; right

b) Is reverse masking required?
1) Yes
2) No

c) Calculate the minimum noise level for BC masking of a pure tone of 2 kHz:

21. In which of the following case Rinne tunning fork test yields false negative response
a. Bilateral SNHL
b. Bilateral conductive hearing loss
c. Bilateral mixed hearing loss
d. Unilateral conductive hearing loss

22. Ideally at what intensity is set for SIS, if the SRT of the patient is at 65 dB?
a. MCL b. 100 dB c. 105 dB

23. What are the frequencies of thresholds are averaged to obtain the PTA
a. 1 kHz, 2 kHz c. 4 kHz
b. 0.25 kHz, 0.5 kHz c. 1 kHz
c. 0.5 kHz, 1 kHz, 2 kHz
d. 0.5 kHz, 1 kHz, 2 kHz and 4 kHz

24. In which of the following cases raising counter is not seen
a. Meniere b. ANSD c. NIHL d. Stiffness tilt of conductive hearing loss

25. Reverse masking is done when
a. Symmetrical hearing loss b. Unilateral hearing loss c. weber lateralized opposite to the better ear PTA.