PROGRAMMED TEXT ON CLINICAL MASKING

An Independent Project in Audiology

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In Partial Fulfilment for the M.Sc. III semester

Examination in Speech and Hearing - May-1980

CERTIFICATE

This is to certify that the independent project in Audiology entitled " Propramned Text on Masking" is the bona fide work, in partial fulfillment for the ".Sc III Semester Examination,carrying 50 marks, of the student with Register No.3

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This is to certify that this independent project in Audiology haS been prepared under My supervision and guidnce.

GUIDE

DECLARATION

This Independent Project in Audiology is the result of My own study undertaken under the guidance of Mr. Jesudas Dayalan Samuel, Lecturer in Audiology,All India Institute of Speech and Hearing, and 'as not leen submitted earlier at ny University for any ther Diploma or Degree.

Mysore

May,1980 **Register No. 3**

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WHY A PROGRAMMED TEXT

A very recently conducted survey (Martin and Pennington,1971) on contemporary clinical procedures showed more disagreement on masking method and apparently greater insecurity than on any one other clinical procedure.

This problem exists eversince the beginning of audiometry. Since then Many authors have been expressing their dissatisfaction, to quote some

"A great deal has been written about clinical masking. Most of it is confusing, much of it is incomplete and a large portion of it is inaccurate and misleading " (Studebaker,1967).

"For some clinicians the approach to masking is a hapazard, hit-or-miss, bit of guess work with no basis in any set of principles." (Sanders,1978).

"Thus the mere fact of having used masking is not enough to insure correct measurement that improper use of masking can itself introduce error" (Menzel,1968).

"Therefore various writers have presented procedures designed to simplify the clinicians task. Unfortunately the simplest procedures provide the greatest opportunity for error " (Studebaker,1967).

Most surprising is that these problems exists even inspite of many clinical audiology books deal separately on masking and though many journal articles appeared.

However when one goes through these books, he can notice

1) that the current texts tend to vary between those which are oversimplified, which may easily lead the student to conclude that masking is a procedure in which one demonstrates his capacity to withstand the pain of memorizing, and others which presume more sophistication than is found among most under-graduate students.

2) some books give only theoritical information and students who stick to these kind of books go 'limp'. And others give only clinical procedure without much theoritical background, and the students who stick to these kinds of books go 'blind'.

3) Many authors describe and emphasize their own method or method of their liking* So students will have to keep switching of text books and they show lot of difficulties in setting on a single text.

4) These books do not provide any chance for the readers who are wishing to test their understanding of different concepts and clinical procedures involved in masking.

The above observations forces one to prepare a programmed text book on masking which is also intended to serve as a basic text in audiometric masking. This programmed text on masking is designed primarily with the naive student in mind. It has as it's basic purpose the presentation of a detailed discussion on clinical masking in a language acceptable to the beginner.

Chapter I

WHAT IS MASKING

All of us have experienced that faint speech cannot be heard in the presence of background noise. Faint speech is said to be masked by background noise. Background noise is called masker and faint speech is called maskee.

Same phenomenon is used in clinical audiometry. Before explaining how masking is used in clinical audiometry we shall consider the definitions of the following terms.

Test ear: The ear for which threshold is to be obtained.

Non-test ear: The ear to be eliminated or "kept busy" with noise.

Test tone: The signal (pure tone or speech) presented to the test ear.

Masker: Masking noise which is generally presented to the non-test ear.

Schematic representation of these terms are given in figure 1.

In clinical audiometry masking signal is applied to the non-test ear. Delivering masking signal to the non-test ear shifts its sensitivity to the test tone to a higher hearing threshold level. This change in the threshold for a test tone by the masking signal is

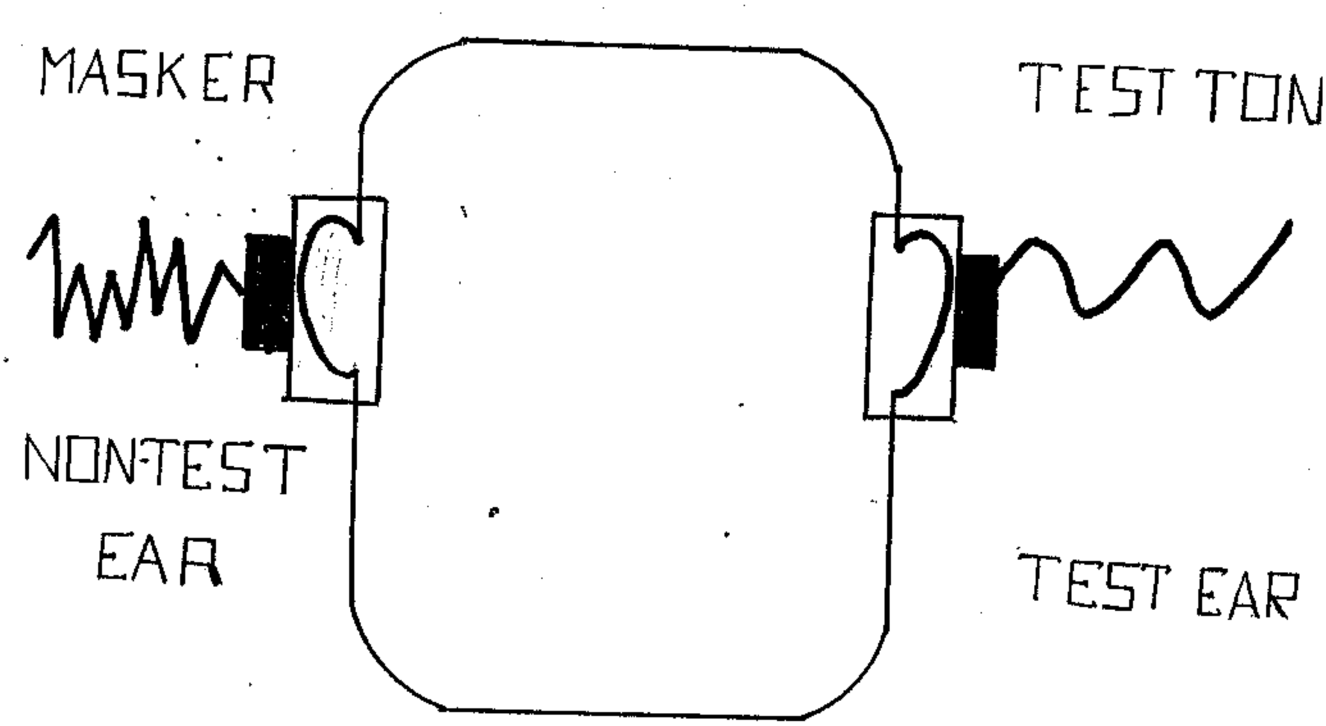


Figure:l Schematic representation of terms necessary to understand masking in clinical audiometry.

called masking. In other words masking signal produces temporary hearing loss in the non-test ear. And whole object of masking is to get this threshold shift in the non-test ear.

Definition:

Masking has been defined variously but for clinical purposes it is defined operationally. Masking is the name given to the psychoacoustic phenomenon where the threshold of audibility is raised by the presence of an another auditory stimulus.

Ipsilaterality of masking:

Masking is fundamentally an ipsilateral phenomenon (Menzel,1968). What this means is that masker can exert masking effect on the maskee only if both masker and maskee are presented to the same ear simultaneously. Exception to.this is central masking (see chapter viii).

This ipsilaterality of masking is basic to it's application in audiometry, since otherwise we could not confine the masking to only one ear any more than the test tone (Menzel,1968).

Conventional technique of masking the non-test ear is supplying the masking noise through an earphone to the non-test ear. This is called cantralateral masking (see chapter viii). Contralateral masking is a useful and wide spread tool in clinical audiometry.

Chapter II

WHY MASKIHG

Masking is used in order to make certain that the test tones are perceived only in the ear which is being tested. To quote Rose (1978) seems appropriate here, " the clinician must take every precaution to insure that when he records results from the right enr he has actually tested the right ear."

To understand the concept "why masking" detailed discussions of the following concepts is necessary.

1. Cross-hearing &
2. Shadow curve

1. Cross-hearing:

In unilateral hearing loss cases or aasymmetrical bilateral hearing loss cases, when we present a tone to the poorer ear, it may be transfered and heard in the better ear well before reaching the threshold of the poorer ear. This is called cross-hearing. According to O'Neill and Oyer (1970) this transfer may be due to

- radiation through air transmission
- transmission through bones of the skull and
- through the head band of the ear phone.

2. Shadow curve:

From the above a pragraph we come to know that the possibility exists that, the patient is hearing tone in his good ear even though we are presenting tone to the poorer ear.- The responses thus obtained without masking are false and constitute a shadow curve (see figure 3).

Cross-hearing in air conduction:

Figure 2 illustrates the cross-hearing. Out of 60dB presentation level, 20dB is reaching the normal ear (cochlea) minusing the interaural attenuation. Since 20dB becomes 0 dBSL for that ear subject starts responding to the tone.

Figure 4 is the audiogram showing 40dB difference between the two ears. Such an audiogram should raise the question about cross-hearing, for air conduction. The audiogram only illustrates the danger of cross-hearing, but does not illustrate cross-hearing as such, since we can not know the individual's interaural attenuation under test.

Figure 5 is the schematic diagram of the mechanism of a cross-hearing in air conduction testing.

Cross-hearing in bone conduction:

It is generally agreed that cross-hearing in bone conduction always occurs. This is because when a bone conduction vibrator is placed on the mastoid the test signal stimulates both cochleas with approximately equal intensity regardless of the placement of the bone conduction vibrator.

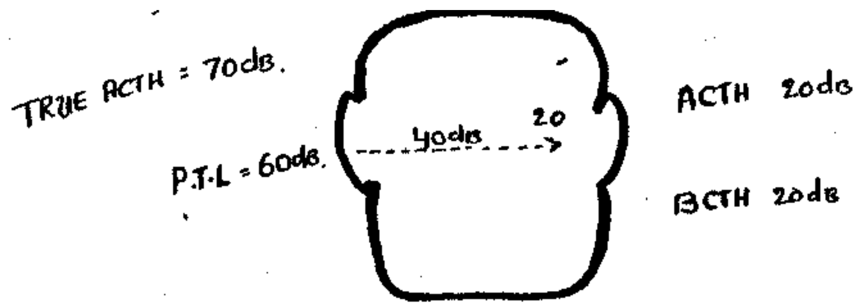


Figure:2 illustrating cross hearing.

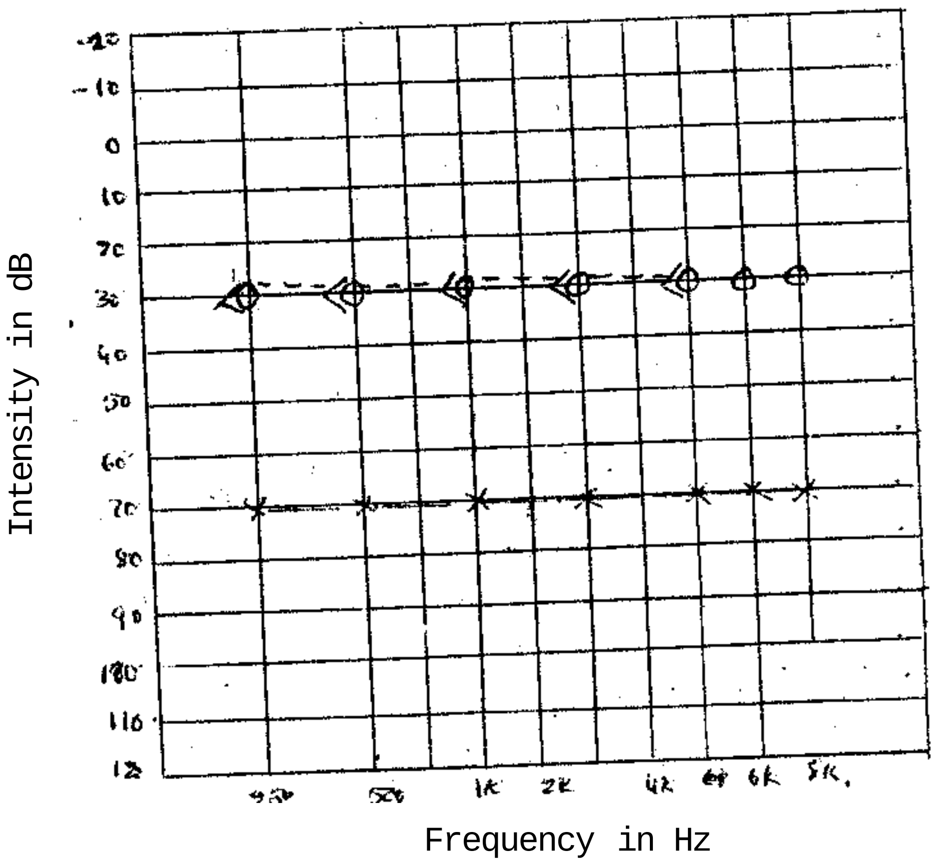


Figure: 3& 4 Audiogram showing 40dB difference between two ears indicating cross hearing.

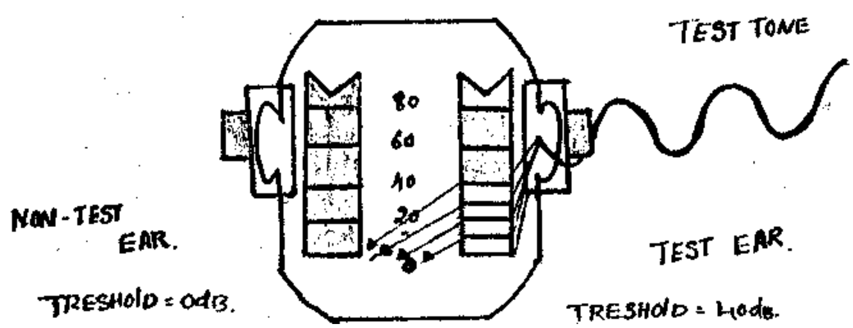
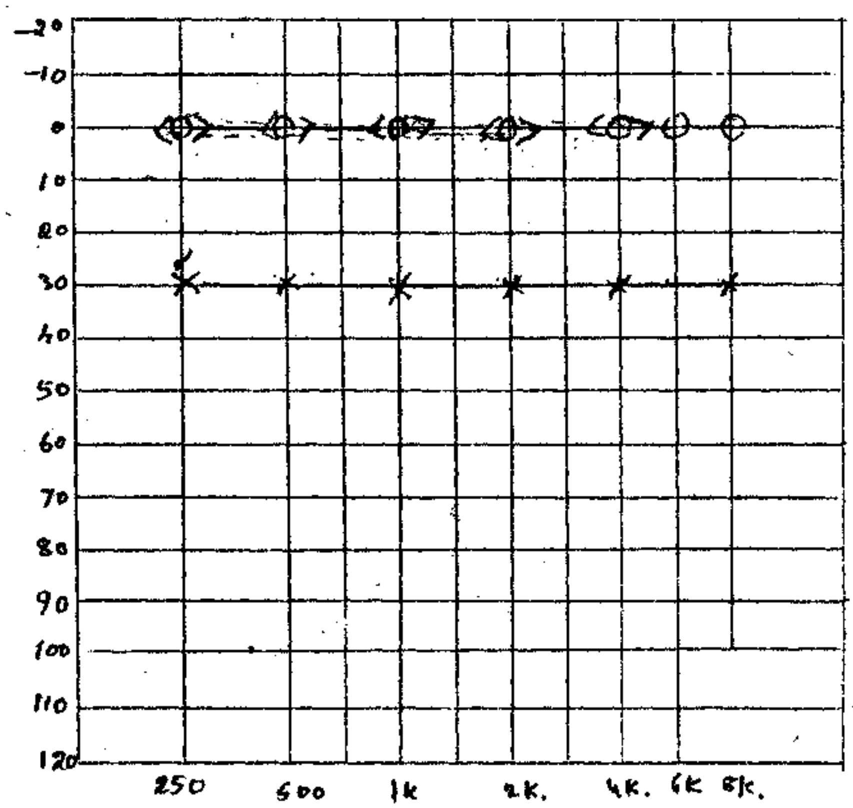


Figure:5 The schematic diagram of the mecahnism of cross hearing in air conduction.

Figure:6 is an audiogram showing an air bone gape with bone conduction obtained in the unmasked condition, indicating cross hearing by bone conduction.



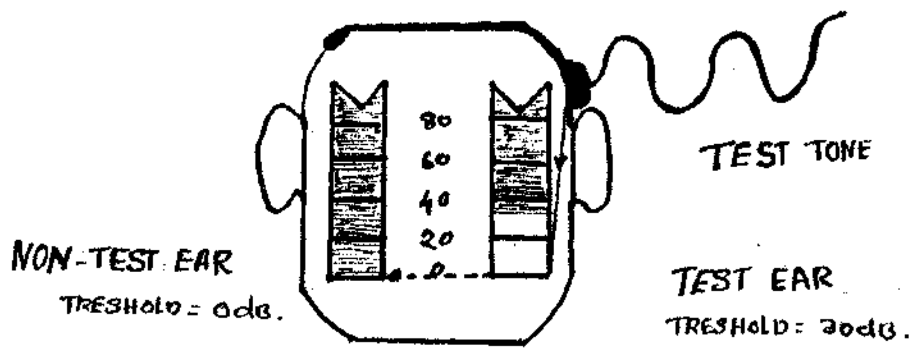


Figure:7 The sqhematic diagram of the mechanism of a shadow curve in bone conduction testing.

Figure 6 is an audiogram showing an air-bone gap with bone conduction obtained in the unmasked condition. This audiogram should raise the question of cross-hearing by bone conduction.

Figure 7 is the schematic diagram of the mechanism of a shadow curve (cross-hearing) in bone conduction testing.

Thus we have understood while testing cases such as unilateral hearing loss and bilateral hearing loss, either by air conduction or bone conduction, some unknown amount of sound energy reaches the better ear constituting false responses. Thus precise specifications of a subject's auditory threshold and supra threshold functions is lost.

In such a condition it is very possible to obtain pure tone threshold indicative of a moderate conductive impairment in an ear with profound sensori-neural loss.

Figure 8 gives an audiogram illustrating an individual having profound sensori-neural loss getting an audiogrgm showing moderate conductive hearing loss. In this instance the test tone presented to the poorer ear by air conduction has reached sufficient intensity to stimulate the non-test ear by bone conduction.The hazardous consequence of this is that the subject may be put into surgery unnecessarily.

In addition, without masking, false results may be obtained in other areas of auditory assessment. For

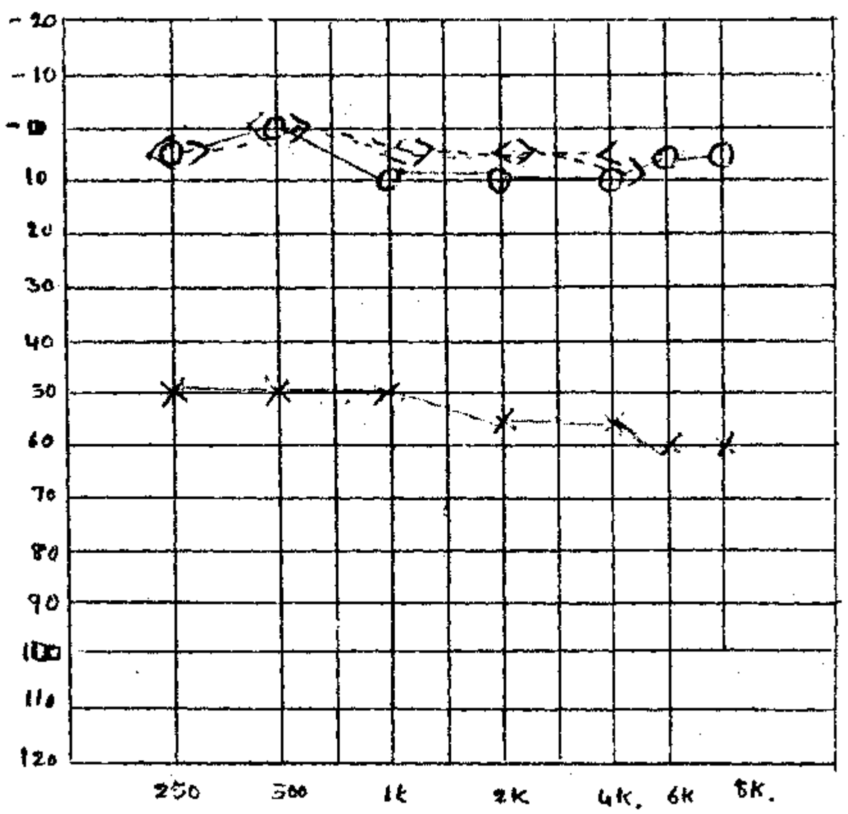


Figure:8 An audiogram illustrating an individual having Profound sensori-neural hearing loss getting an audigram showing modernte conduotive impolrment.

example in speech audiometry, a reasonably good discrimination score may be obtained in an ear with severely impaired speech discrimination. Based upon this false result, a clinician may prescribe an hearing aid which is actually not useful to that ear. Similarly even in special tests like tone decay, we may obtain moderate tone decay in an ear with highly abnormal adaptation.

Thus the participation of the non-test ear should be ruled out, and this is the purpose of masking, Masking isolates the non-test ear from the test ear, so that valid thresholds can be obtained for the ear under test.

The participation of the non-test ear is prevented by keeping it "busy" with masking signal. When the masking signal is introduced in the non-test ear it results in a temporary downward threshold shift, for the test tone And thus the subject will not hear tone in the non-test ear. For example 20dB is reaching the non-test ear (figure 2), and if we give 50dB noise to the non-test ear, he will not hear the tone in the non-test ear. In order to he hear the tone in the non-test ear in the presence of the 50dB noise presentation level in the test ear should reach 75dB. Since his actual threshold is only 70dB (of poorer ear) he perceives 70dB tone in the poorer ear but not in better ear. Thus participation is ruled out, and actual threshold of the poorer ear is obtained.

Chapter III

HOW TO MASK

In the previous chapter it was mentioned that the participation of the non-test ear is prevented by keeping that ear busy with masking signal. The objective of this chapter is to wake the student familiar regarding,

- How the masking signal is introduced?
- What are the kinds of masking signal and their advantages and disadvantages and finally
- Their relative masking efficiency.

How the masking signal is introduced?

Conventionally participation of the non-test ear is ruled out by supplying masking signal through an earphone to the non-test ear. Menzel (1968) calls it conventional masking.

Types of masking signal

A variety of signals have been used in clinics as Bmasker: They range from simple pure tones to utmost complex speech.

1. Pure tones:

Pure tones have been used to mask pure tones only, since they cannot mask complex signals like speech.

Masking effect is greater when the masking tone and the masked tone are closer toguther or when the masking tone is higher in intensity (Glorig,1966).

Masking effect determined by a sound is much stronger on the frequencies higher than on those lower (Portman & Portman,1961).

One can therefore use a tone whose frequency is below and closer to the one being examined. For example 500Hz tone to mask the perception of 1KHz tone.

Disadvantages:

Masking of pure tones by pure tones is

- very confusing and
- complicated by the fact that distortion , products may arise for example combination of tones.

These disadvantages are almost certain if both maskee and masker are closer in intensity and frequency.

2. Warble tones:

Warble tone is produced by frequency modulation and is a periodic variation of a base or center frequency with amplitude held constant.

Masking of pure tones with warble tone is characteristic of masking pure tones with narrow band noise (Staab,1974).

However this is not a commonly used masking stimulus.

3. Masking by means of compressed air:

Aubry and Girard (1961) have compiled this process.

This method consists of a bottle of compressed air which is connected to a tap and monometer. From this tap, gas is released through a rubber tubing to a nozzle which is placed in the ear of patient.

When the gas is expanded and projected on the ear drum,it results in a whirling noise.

Again this method is not being used since we are provided with simple and efficient masking noise sources in our modern audiometers.

4. Noise

Masking of test tone in the non-test ear by a pure tone, warble tone, or by weans of compressed gas has been outdated for the reason one or the other. Therefore in almost all practical instances of masking involve, masking of a pure tone and speech by noise.

Thus a standard and a conventional procedure for clinica masking is to place an ear phone over the non-test ear and introduce noise to that ear. The following types of noise are used.

4.a. Complex noise:

Complex noise is a type of broad band noise having a low frequency fundamental plus the multiples of the fundaments Usually the base frequency varies between 60Hz to 120Hx. See the acoustic spectrum (figure,9). The fundamental frequency for this particular noise is 62.5Hz. The additional frequencies present are 125,250,500,l000Hz etc.

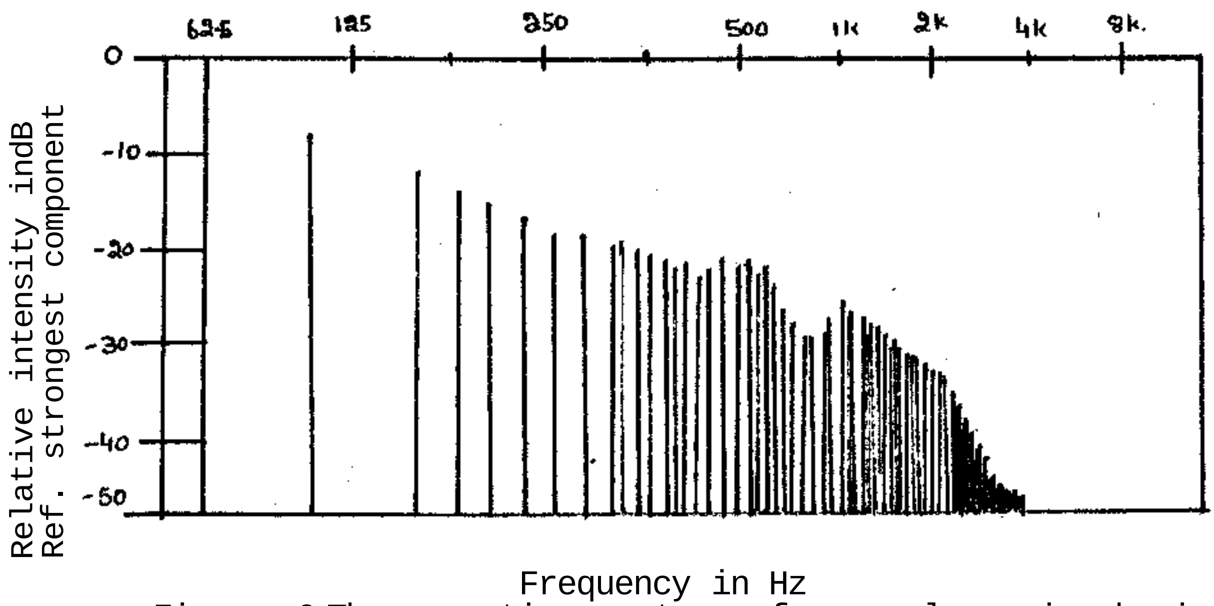


Figure :9 The acoustic spectrum of a complex noise having a fundamental frequency of 6OHz and the amplified multiples of that frequency.

Acoustic energy is present upto 4KHz. But energy is present only at discrete frequencies indicated by verticle lines) i.e energy is not present between 62.5 and 125, or between 125 and 250Hz. And also energv decreases as frequency increases. By 4KHz energy drop off is greater than 50dB. And energy is not all present after 4KHz.

The noise has a buzzing like quality and masks most effectively in the lower frequencies where the energy is greatest (Staab,1974). As a result of this noise has little or no effect in masking high frequency tones.

Under this complex noise two types of noise are generally discussed.

4.a.l. Squarewave noise:

This complex hormonic signal is achieved by generating a squarewave and taking it's hormonics (Staab,1974).

4.a.2. Saw tooth noise:

This complex hormonic signal is achieved by generating a saw toothed wave and taking multiples of the basic repetition rate (Staab,1974).

Disadvantages of complex noise:

1. Since energy is only present at discrete frequencies, it is possible for a given component of the noise to be within 3 or 4 cycles of the test tone producing a beat (Sanders,1978). For example eighth hormonic of the 62.5Hz fundamental frequency will beat with a test tone of 500Hz.

2. The second disadvantage is that the energy decreases as 'the frequency increases. Thus it is effective only at lower frequencies.

Because of these two limitations it seldom appears in modern clinical audiometers.

4.b. Broad band noise:

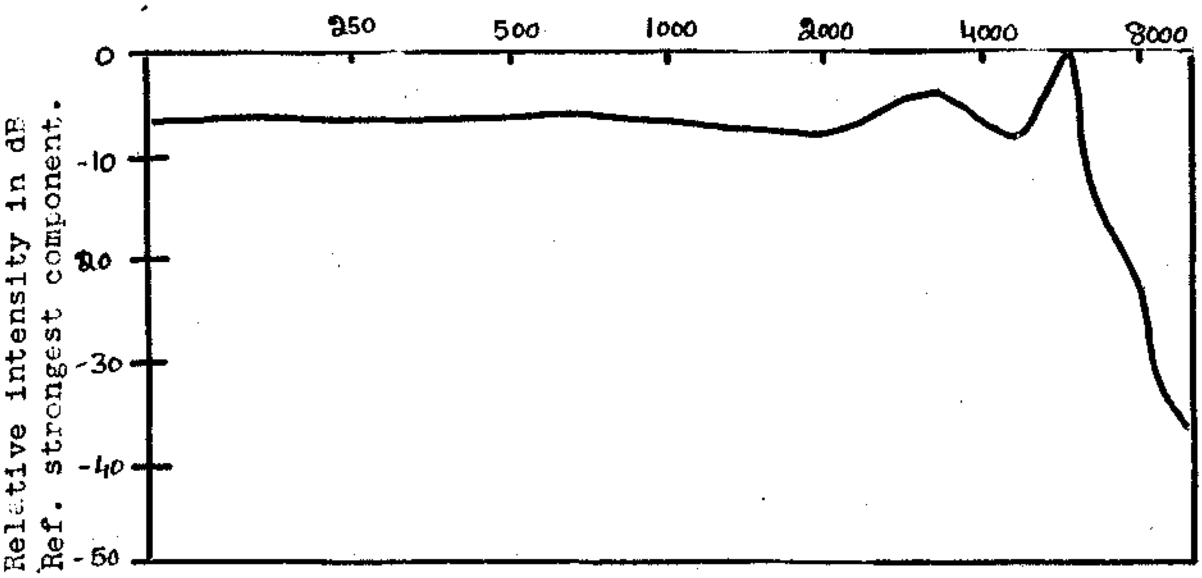
Clinically it has beecn called variously, such as wideband noise, thermal noise, and white noise. Rose (1978) suggested that it should more properly be referred to as broad band noise (may be because of greater band width).

This theoritically contains all of the frequencies in the audible spectrum at approximately equal intensities. However, the spectrum is limited at the ear by the frequency response of the earphone as can be seen in figure 10.

Of thse two types of noises(complex noise and bread band noise) white noise haw greater masking efficiency, atleast in the middle and higher frequencies since it's spectrum is essentially flat; where as energy in the complex noise is concentrated in the lower frequencies with a rapid drop off energy in the middle and higher frequencies (Sanders,1978).

Advantages:

- Has got uniform energy throughout the audible spectrum.
- Maximum masking for broad band noise is higher than narrow band noise. But according to Studebaker (1962) the range of permissible masking for the two types of noise is approximately the same. He says



Frequency in Hz

Figure:10 The acoustic Spectrum of broad band noise through an audiometric earphone.

although maximum masking tor broad band noise is higher than for the narrow band noise it's minimum masking is also higher. Thus the range of permissible masking is same for both narrow band noise and broad band noise.

Disadvantages:

- Only the noise components within a narrow frequency band surrounding the test tone, contribute to the masking of the tone (see critical band concept).
- The rest of the noise spectrum not only unnecessary hut also increases the intensity of noise and thereby reducing the threshold of pain.

4.c. Narrow band noise:

Narrow band noise is not a third kind of noise, but is produced by selectively filtering white noise. It is generally agreed that narrow band noises, centered at the test signal frequency are the most efficient maskers of pure tones. Thus for pure tone audiometry, the filters are set to produce a band offrequencies with the test tone at the center of the band. Thus nprrow band noise generator is nothing but a white noise generator with filter network which varies depending upon the test tone frequency. Thus l000Hz narrow band signal would he white noise in a limited band frequencies with 1000Hz at it's center.

These band widths are usually described by their

1. Band width

is the frequency range whose energies are no more than 3dB below the strongest component.

2. The rejection rate

is the decrease in intensity over a range of one octave on either side of the band.

3. Center frequency

The acoustic spectra of five narrow hands of noise is shown in figure 11.

Advantages:

- Narrow band noise will be wore efficient because it can raise the threshold of the non-test ear with less overall energy and therefore be further below the threshold of pain. So less fatigue and discomfort.
- Allard (1974) while determining the relative distractability of wide band noise and narrow band noise, concluded that narrow band noise is preferable due to less distraction.
- The use of narrow band noise offers the further conveniences that each band can be calibrated in effective level independently. Thus, the numerical masking dial reading equals the test signal intensity that will be just masked at all test tone frequencies (Studebaker,1967).

Because of these advantages narrow band noise almost appears in all newer clinical audiometers.

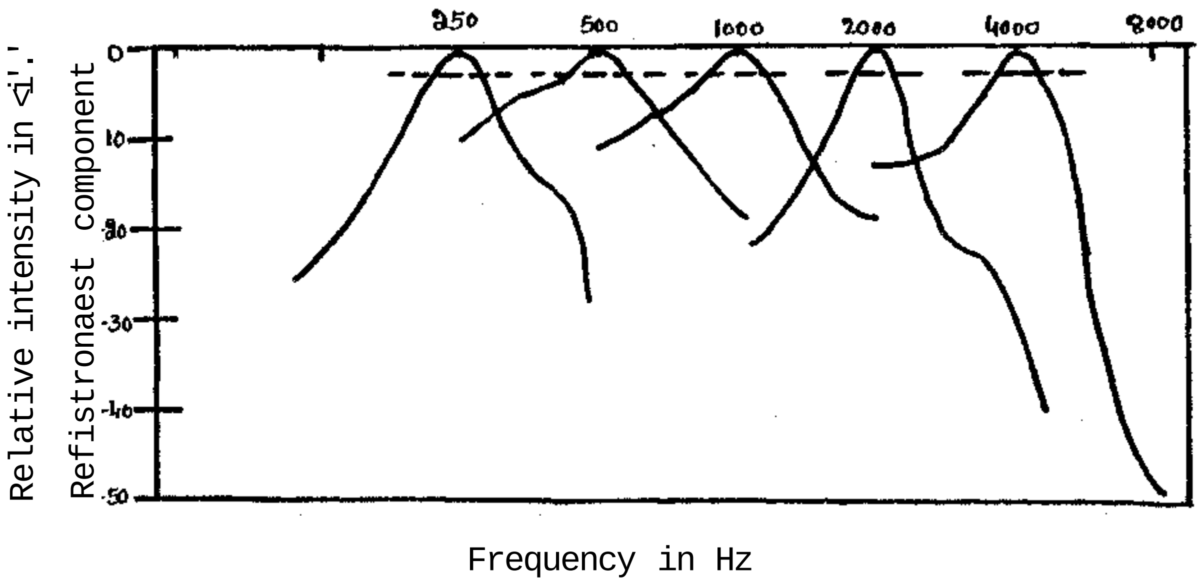


Figure :11 An acoustic spectra of five narrow bands of noise.

However, Glorlg (1966) is of the opinion that the narrow band masking noises are considerably more expensive, since a separate narrow band masking noise is required for each test freqency. In this regard to quote Palva & Palva (1954, 1958) as quoted by Studebeker (1967) " the gain in efficiency over broad band noise is not sufficient to justify the additional cost and complexity of narrow band noise generators."

4 .d. Speech noise:

Speech noise is again an outcome of white noise. It is obtained by filtering white noise above l000Hz at the rate of about 12dP per octave. Thus it has more energy in the low frequency spectrum than white noise and resembles the spectrum of speech.

4.e. Pink noise:

It provides a relatively broad spectrum with equal energy per octave below about 2000Hz.

Relative Masking Efficiency

We have understood that out of 4 masking signals mentioned, noise is most efficient masker of all. And also we know several kinds of noise are avialable for clinical purpose. All types of masking noises are not equally efficient. Efficient noise is one which produces given threshold shift with least overall intensity. Thus the amount of threshold shift produced by a masking noise depends not only on the intensity of masking noise but also on the nature of the masking signal.

And also some noises are more efficient in masking pure tones whereas others are more efficient in speech signal masking.

A manufacturer has got several kinds of noise at his disposal for the clinician. The clinician just cannot select any one of them randomly. An important factor in choosing among the available masking noises is the relative masking efficiency of the noise.

The masking efficiency of a noise is the relationship between it's overall intensity level and the magnitude of the threshold shift produced by that noise (Sanders, 1978).

Why some noises are more efficient than other noises? To understand this the reader should know 'critical band concept.'

Critical band concept

Early work by Fletcher (1937 & 1940) pointed out that when masking with broad band noise, the only components of the noise effectively masking were those whose frequencies were within a narrow band around the test tone frequency.

Sanders (1978) states the concept in two parts:

1. In masking a pure tone with a broad band noise,

the only components of the noise having a masking effect on the tone are those frequencies included in a restricted band with the test tone at. it's centre.

2 . When the pure tone is just audible in the presence of noise, the acoustic energy in the restricted band of frequencies is equal to the acoustic energy of the test tone.

The first part of the concept coveys that, only the energy in the noise in the frequency band immediately surrounding the test frequency contributes to the masking of that frequency. And the width of the restricted band frequencies responsible for masking a pure tone is critical. Sanders (1978) says, if a band is narrowed to less than the critical width without adding to the energy within the band, it's masking effect is decreased. If the band is widened beyond critical width it's masking efficiency is decreased.

The second part conveys that the effectiveness of the masking noise is determined by the spectrum level within the critical band, often referred to as the level per cycle, rather than overall intensity which has no masking effect.

This concept is specific to a noise of continous and flat spectrum and will not hold entirely true for complex noise.

Application of critical band concept

Application of critical band concept is to findout the masking efficiency of different masking signals by finding out the noise level per cycle.

Level per cycle is the overall sound pressure divided by the number of cycles. While calculating the level per cycle frequency value should be converted to it's logarithm, and the function the becomes one of subtraction.

Let us consider one example:

80dB white noise and 80dB narrow band noise (band width is 200Hz)..

In case of white noise 80dB energy is distributed throughout 6000Hz range whereas in narrow band noise 80dB is just distributed over 200Hz range. So naturally, level per cycle is highest in narrow band noise than in broad band noise. Thus at equal over all intensity we would expect greater threshold shift from narrow band noise. In other words, for a given threshold shift the overall intensity would be less for the narrow band noise.

Formula for calculating level per cycle:

Level per cycle(PC) = overall intensity minus 10 times the logarithm of the band width.

LPC = O.A SPL - 10 log band width

(Note: For critical band widths of eleven test frequencies see the table given in Chapter V).

Experimental verification of critical band concept

Relative masking efficiency of noises can be verified through actual threshold measurement. Student is referred to the title " determination of effective masking level " under the chapter " How much masking."

What types of masking noise are recommended for pure tone masking

The discussion on critical band concept has clearly shown us the superiority of the narrow band noise over other kinds of noises in pure tone masking.

Thus narrow band noise is the preferred noise for use when masking pure tones for the following reasons

1. It provides more efficient masking than broad band noise and complex noise.
2. The overall SPL is not as great as broad band noise and is not disturbing to the subject.

What types of masking noise are recommended for speech audiometry.

Speech signal is a broad spectrum signal. So a broad spectrum signal should be used to mask speech signal. Since pure tones and narrow band noises are not broad spectrum signals, they cannot be used in speech masking.

Following types of signal are being used to mask the speech signal.

1. Complex noise:

Not ideal for speech masking owing to the high frequency weakness of complex noise (Martin,1978).

2. Broad band noise:

Broad band noise is used most frequently for speech audiometric testing. Speech contains all frequencies and must be masked by a noise containing comparable frequency composition.

According to Martin (1975) this is slightly weak in lower frequencies. May be this is due to the fact that the normal ear is significantly less sensitive to frequencies below about 500Hz than to frequencies Rom about 500 to 4000Hz (Glorig,l966).

3. Speech noise:

Since ppeech noise resembles the speech signal spectrum, Martin (1975) speech noise as the best considers masking device for masking speech.

4. Pink noise:

uyavenes and Sohobl (1967) while finding out the relative efficiency of pink noise and white noise in masking speech concluded that "pink" noise seems to he preferable as a masker of speech because of the following reasons:

1. Masking effect of pink noise is l-4dB greater than white noise.
2. The increase in masking with the increased noise intensity is linear with " pink noise?

Chapter IV

WHEN TO MASK

" It is not always necessary to mask,and the questions of when to mp.sk are the ones that many clinicians find it trouble some." (Rose,1978)

" The understanding of when to mask places the tester half way toward the goal of properly using masking in pure tone testing"(Staab,1974).

Anser to the question " when to mask"is very simple. Masking should be applied to the better ear whenever the danger of cross hearing is indicated. The danger of cross hearing is determined by the following factors.

i. Presentation level of the test signal (PTL)
ii. Interaural attenuation (IA), and .
iii. Threshold sensitivity of the non-test ear.

Since interaural attenuation varies with mode of conduction (air or bone) and also with type of signal (pure tone or speech), so we get different Interaural attenuation values (see interaural attenuation). And since interaura) attenuation is one of the main factor in determining the danger of cross hearing, we have different rules for "when to mask" in pure tone air conduction, pure tone bone conduction and in speech audiometry. Because of this reason the chapter has been divided into three subdivisions. They are:

1. When to mask in pure tone air conduction
2. When to mask in pure tone bone conduction
3. When to mask in speech audiotnetry.

Before going to these rules we shall discuss in detail about above said 3 factors which determines the danger of cross hearing.

1- Interaural attenuation (IA)

Interaural attenuation is the reduction in the intensity of sound in passing from one ear to the other ear. This is also called as skull attenuation, interaural transmission loss.

Definition:

Zwislocki (1953) defines interaural attenuation as the reduction in the intensity of a signal fed to one ear after crossing the head to the opposite ear.

Wegel A Lane (1924) and Zwislocki(1948) consider this interaural attenuation to be due to bone conduction, meaning, as sound travels from one ear to the other ear primarily by vibrating the bones of the skull, it looses energy. Bekesy (1948) opined that interaural attenuation is mainly due to air conduction. Chaiklin(l967) says that at certain frequencies there exists some air conducted leakage.

However, most authors seem to favor the explanation given by Wegel & Lane (1924) and Zwislocki (1948).

Amount of interaural attenuation is not same. It varies with,

a. Kind of signal
b. frequencies
c. Types of earphones used
d. Mode of conduction of signal
e. Across subjects and
f. Miscellaneous factors.

a) Interaural attenuation and kind of signal

Kind of signal here means, whether signal is pure tone, speech or noise. The interaural attenuation values are different for different stimuli. So it is recommended that clinicians should consider different interaural attenuation values for different stimuli. For example Vijayaraghavan (1978) found mean interaural attenuation value for pure tone and narrow band noise to be 58 and 65dP respectively.

b) Interaural attenuation across frequencies

To see how interaural attenuation changes across freq- uencies see tables given by Coles & Pride (1968), Zwislocki (1953) and Vijayaraghavan (1978). See table 1.

Interaural attenuation values between authors differs perhaps because of type of earphone used,type of subjects or measurement method.

c) Interaural attenuation and kinds of earphones

Larger the earphone less the attenuation, smaller the earphone more the attenuation vajue. Size of the ear phone is indirectly proportional to the amount of interaural attenuation (sec insert receiver,chapter number ix).

Table:1 Mean and range of interaural attenuation values according to different authors

Author		125	250	500	1K	2K	4K	8K
Zwislocki (1953)	Mean	40	40	50	55	60	65	70
	Range	-	-	-	-	-	-	-
Coles & Pride, (1968)	Mean	-	62	63	63	68	68	-
	Range	-	50-80	45-80	40-80	45-75	50-85	-
Vijaya-raghavan (1978)	Mean	-	46	57	58	60	66	58
	Range	-	45-49	55-59	58-59	60-61	65-68	56-59

d) Interaural attenuation and mode of conduction of signal

Signals can reach cochlea either through air conduction or bone conduction. When signals are conducted through air conduction interaural attennution is much larger than when conducted through hone conduction. The interaural attenuation in air conduction amounts to 40 to 85dP depending upon frequency (Coles & Pride,1968). Whereas in bone conduction interaural attenuation amounts to 5 to 15dB (Studebaker,1967). For the mechanism of interaural attenuation by air conduction and bone conduction see the figure 12 & 13 respectively.

e) Interaural attenuation and individual differences

Interaural attenuation varies from person to person, even when we use same frequency tone, same earphone, and same mode of conduction. For example in coles & Pride's (1968) study at 1KHz minimum interaural attenuation was 40dB and maximum was 80dB (see table 1 for details).

f) Miscellaneous factores

Interaural attenuation may vary depending upon the external auditory canal's volume. Vijayaraghavan (1978) studied the head circumference as a variable in interaural attenuation. And He concluded that the interaurnl attenuation value may not differ significantly as a function of the size of the head.

Thus knowing these figures for the skull attenuation of pure tones or speech and knowing the levels of test signals presented to the test ear one can easily calculate the intensity of the sound stimulating the non-test ear.

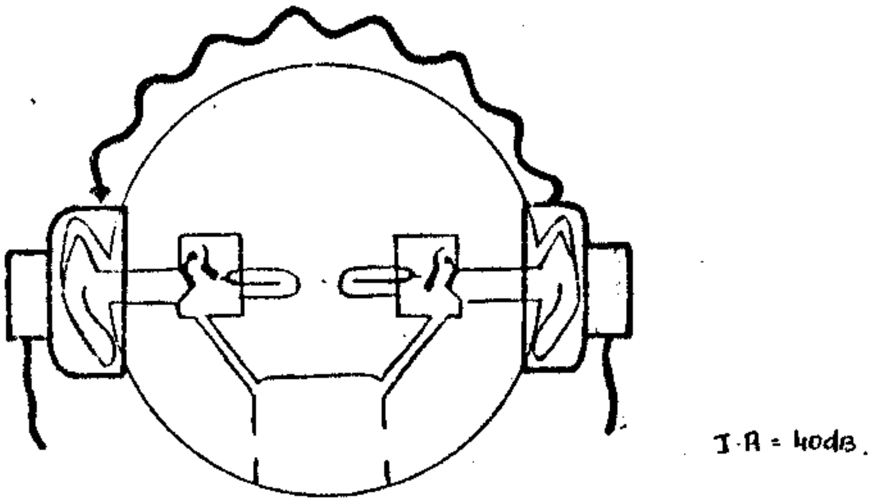


Figure:12 Mechanism of interaural attenuation for air conduction.

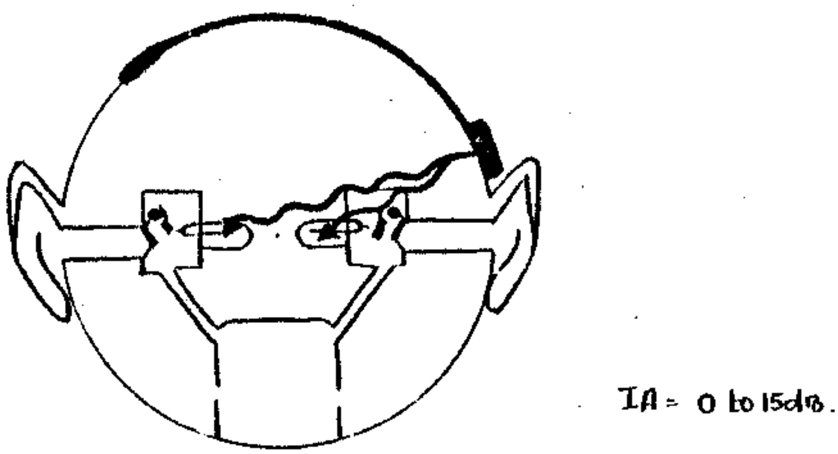


Figure:13 Mechanism of interaural attenuation for bone conduction.

In the same way the possible effect of the masking noise on the threshold of the opposite inner ear (test ear) can be estimated or calculated.

2. Presentation level of the test tone

It is the level of the test tone, presented to the unmasked ear. This presentation level minus the interaural attenuation is level of test tone reaching the opposite ear. After a particular point, ''when presentation level becomes more than 40dB) the level of the test tone reaching the non-test ear is linear with the presentation level.

3. Threshold sensitivity in the non-test ear

Even when the test signal is presented by air conduction it will cross the skull by bone conduction. Thus the threshold sensitivity of non-test coch.ea plays an important role. Higher the threshold sensitivity of the non-test ear's cochlea, lesser the danger of cross hearing and vice versa.

I. When to mask in p u r e tone_air conduction

It is generally agreed that test tone travels to the opposite ear primarily through hone conduction, irrespective of mode of conduction of pure tone signal. Thus rule for when to mask should be brsed on the 'sensory-neural'sensitivity of the non-test ear, but not on air conduction threshold of the non-test ear. This is illustrated in the audiograms, figure number 14 & 15.

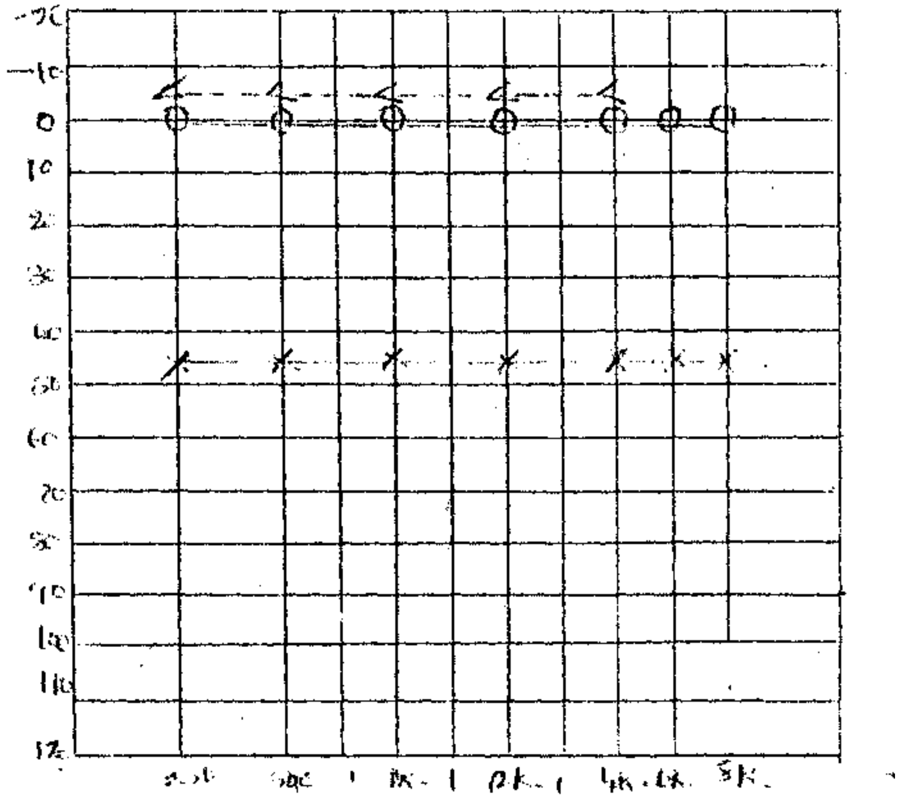


Figure :14, An audiogram illustrating the need to Mask the right ear, to establish the thresholds of left ear "because difference between left air conduction threshold and right bone conduction theshold is more than 40dB.

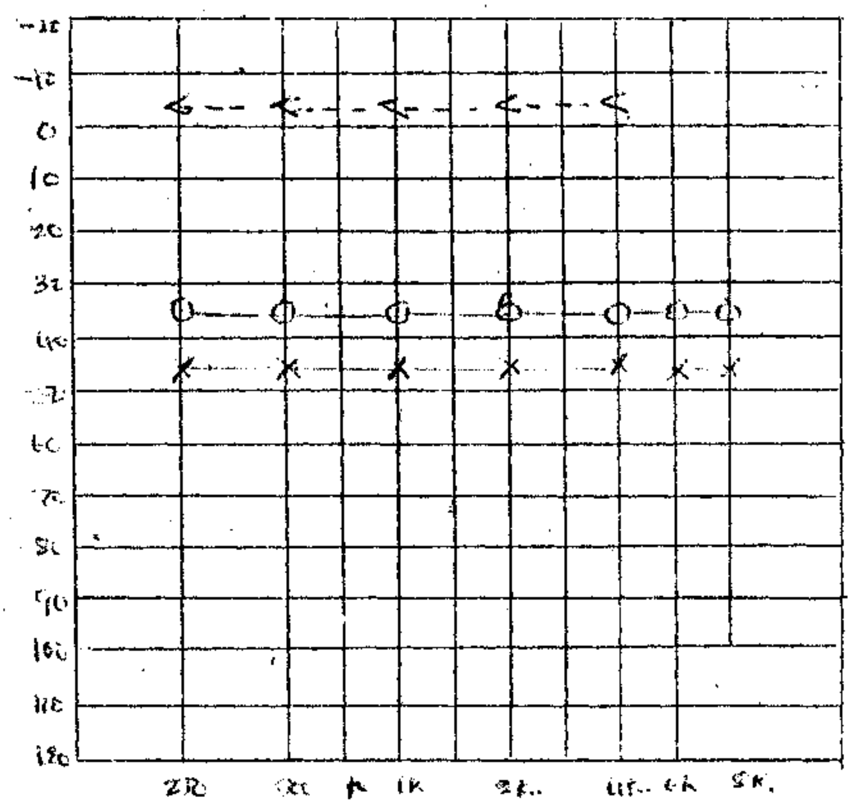


Figure:15, An audiogram illustrating need to mask the right ear while reestablishing left ear conduction thresholds though, difference between right and left air conduction thresholds is only 10 dB. This is because the gap between air conduction threshold of left ear and the bone conduction threshold of right ear is maintained.

In figure 14, audiogram shows that right ear is within normal limits both airconduction bone conduction). Left air conduction responses are" around 45dB. Danger of cross hearing is indicated because difference between unmasked left air conduction threshold and right bone conduction threshold is more than 40dB. Also there is a gap of more than 40dB between right air conduction and left air conduction which should not be considered. This is illustrated in the figure 15.

In figure 15, audiogram shows only l0 dB gap between left air conduction and right air conduction, still shadow responses occured at 50dB. only, because the gap between air conduction of the left ear and bone conduction threshold of the right ear is meintained in both the radiograms.

Thus when to mask should be based on sensory-neural sensitivity in the non-test, ear,(first factor).

Secondly an air conducted tone to travel from test ear to non-test ear, the amount of energy lost ranges from 40dB to 80dB (see interaural attenuation), depending upon frequency, and subject. In this situation it is reasonable to adopt the Studebaker's (l967) suggestion of taking an extreme value. In this case we should take minimum value i.e 40dB (second factor).

Now with the help of thrid factor i.e presentation level of the test tone we can arrive at rule for when to mask.

Presentation level - Interaural attenuation Z Bone conduction threshold of non-test ear.

Symbolically,

$$PTL - IA \geq BC_{NTE}$$

(or)

$$PTL \; Z \; BC_{NTE} + IA \text{ (for tone)}$$

In the above audlograms 14 & 15 the presentation level of test tone is greater than bone conduction threshold of non-test ear + interaural attenuation for tone. Thus masking is needed in both the cases.

In other words, it is necessary to mnsk whenever the airconduction presentation level at the test ear exceeds the bone conduc ion threshold of the opposite ar by more than the smallest expected interaural attenuation value (Studebaker,1967).

Here the smallest expected interaural attenuation value is taken since we have no way of finding out the person's interaural attenuation under test. This is a conservative approach and may result in the use of masking when it is not needed. However, the use of masking when it is not needed is a much less serious problem than not using it, when it is needed (Rose,1978). Sticking to the above suggestion will result in the fewest number of serious mistakes.

Take for example the same audiogram (F.number 14). His left airconduction responses are at approximately 50dP. These responses could be,

-Shadow responses (if interaural attenuation is 40 to 50dP), or

-Actual responses of right ear (if his interaural attenuation is say, 65dB), if this is the case no need to mask. Put we do not know his interaural attenuation. So take his interaural attenuation to be minimum and mask and no harm is done.

Again by following this rule there may be times when the nerd to mask for air conduction is not apparent until bone conduction thresholds have been obtained (Lydd & Kaplan,1978).This is illustrated in the audiogram,(FIG.16)

In the same audiogram if right bone conduction is also 30dB, there is no need to mask. If bone conduction is 10 dB or below danger of cross hearing exist indicating need for masking. Thus need for risking, cannot be decided until we'hrve bone conduction threshold.

In such a situation one can follow Palva's (1962) suggestion, as wiltten by Studehaker '1967) " Palva(1362) proposed masking the opposite ear whenever the air conduction presentation level exceeds the smallest expected interaural attenuation value."

Symbolically,

When PTL>40dB mask the opposite ear.

II. When to mask in bone conduction

Since at low frequencies the skull vibrates as a unit, the two cochlea imbedded within the same skull, are stimulated almost equally regardless of whether the receiver is

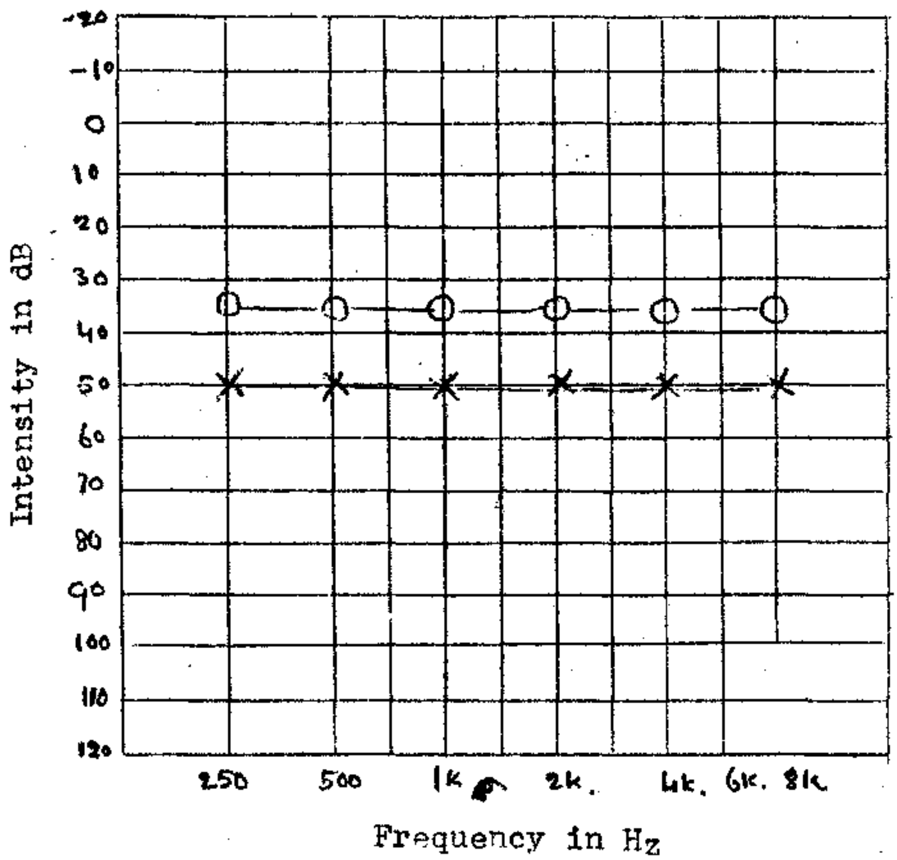


Figure:16 An sudiogram illustrating the need to mask for air conduction testing is not apparent auntil bone conduction thresholds are obtained.

on the same or opposite side of the head. At higher frequencies attenuation on the order of l0 dpxmay be obtained but varies cross subject so it is not reliable.

Because of these reasons, many authors suggest interaural attenuation for bone conducted signal should be considered as zero dB.

When we get an audiogram, as shown in figure 17 the bone conduction results plotted on the audiogram could actually represent the right ear, left ear, or both ear since interauraL attenuation is considered as zero.

Since interaural attenuation is considered as zero it has been suggested that masking always be used in bone conduction testing (Glorig,1963; Staab,1975).

Menzel (1968), donot accept such an conservative approach, and argues against it, saying that validity and reliability of threshold measurement tend to be better when masking is not used. And he says it is therefore meaningful to specify the conditions underwhich masking is not indicated rather than when it is.

He lists the following 3 conditions underwhich masking is not done, but in al1 other conditions.

- Masking for bone conduction is not necessary when the thresholds obtained without it are approximately equal to the air conduction threshold for that ear.

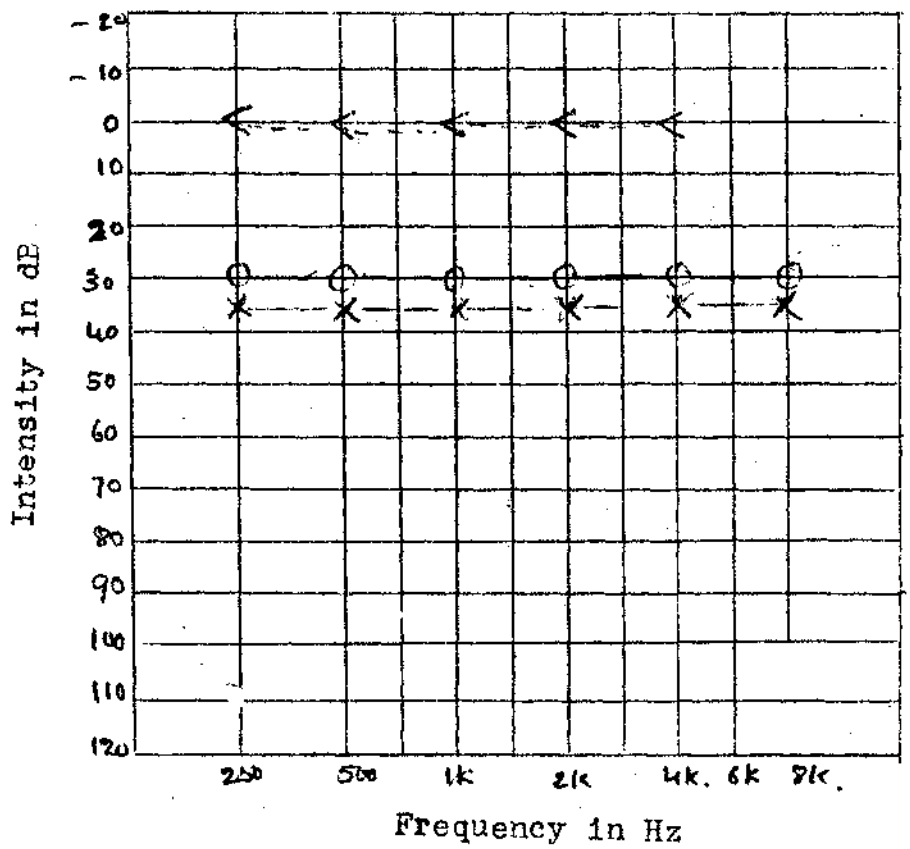


Figure:17 The bone conduction thresholds on the audiogram could actually represent the right ear, left ear or both since interaural attenuation is considered as zero.

- It is not necessary when unmasked bone conduction thresholds for the ear beineg tested are better than those for the opposite ear (although mnsking will probably have to be used when the other is tested).
- Masking for bone conduction is obviously unnecessary when the sound fails to be heard at the upper bone conduction testing limits o the audiometer being used.

Studebnker (1964) objecting to the conservative approach saying that it is more conservative than necessary recommends masking should be used any time the bone conduction thresh-olds are better than air conduction thresholds in the ear being tested by more than 10dB.

Weber test had been used for determining when to mask during bone conduction test. If the patient lateralizes the weber test tone one ear then masking noise is applied to that ear. No masking is needed, if the subject does not lateralize the tone. However, this procedure is not being used because of misleading results.

III- When to mask in Speech Reception Threshold measurement

In speech reception threshold measurements spondee words are used as test stimuli. The beginning student traditionall has been left to his own imagination with regard to when cross hearing for spondee words may occur and what measures should be taken to avoid this (Martin,1978).

Contralateralization for speech stimuli occurs through bone conduction similar to contralateralization for pure tone stimuli. Hence the same 3 factors determine the danger of cooss hearing. They are,

- Presentation level of the test signal (spondee words)
- Interaural attenuation and
- Threshold sensitivity of the non-test car.

Minimum interaural attenuation for speech is considered to be 40 to 50dB (Martin,1975). Owing to the use of large earphones the interaural attenuation value is set at 40dB. This may lead to unnecessary masking in some cases. However, the risk of loosing some accuracy must be accepted as a far lesser evil than shadow responses (Menzel,1963).

Thus cross hearing is a danger whenever the speech reception threshold of the test ear minus the interarual attenuation is equa1 to or above the bone conduction threshold of the non-test ear.

Since speech is a complex signal and hone conduction thresholds are obtained with pure tones, it is probably best to compare the test ear's speech reception threshold with the best bone conduction threshold of non-test ear.

Symbollically, mask when

$$SRT_{TE} - IA \geq Best\ PCT_{NTE}$$

or

$$SRT \geq Best\ BCT_{NTE} + IA$$

Reader will recall that while determining When to mask in case of pure tone testing (both air conduction and bone conduction) presentation level in the test ear was compared with bone conduction threshold of the non-test ear. And air conduction threshold of the test ear was unrelated to the danger of cross hearing. Similarly here since mechanism of cross hearing for speech and pure tone is considered same, the speech reception threshold of non-test ear are unrelated to the danger of cross hearing.

Chapter V

HOW MUCH MASKINS

I.In threshold audiometry

Till this chapter the student has learnt about what is masking, why msking should be used, what kind of masking noise should be sued in different tests. If the student has thoroughly understood these concepts, one can easily say he has understood 50% of masking. The next 50% which he has to achieve lies in understanding how much masking noise is appropriate to the non-test ear so that he can measure exact thresholds of the test ear.

Student may wonder why so nuch of weightage i.e 50% is given to this chapter. This is not without reasohable reasons.

"It may be seen that the problem of obtaining true threshold responses from a poorer ear might not be over-come in many cases simply by putting a noise into the opposite ear" (Sanders & Rintlemann,1964).

"More errors are committed in audiometry through careless or improper use of masking than through it's omission. Most of these errors result from either too much or too little masking" (Menzel,1968), and

"Avoidance of improper masking intensities requires consideration of a number of factors including the test signal level, effective level etc. Few clinicians find it feasible to manipulate all these number of variables in day to day clinical practice (Studebaker,1967).

The optimum intensity of the masking signal should satisfy the following two conditions given by (Portman & Portman,1961).

1. Criterion of efficiency:

That is the masking tone should very effectively mask the ear to be eliminated. This criterion strosses upon the minimum effective amount of masking noise in the non-test ear.

2. Criterion of repercussion:

That is the masking noise should have no repurcnssion in the ear being tested. In other words the masking noise in the non-test ear should not influence the thresholds of the test ear. (fcourse beyond central effect (see central masking,chapter number viii). This criterion stresses upon amount of maximum noise one can use without affecting the thresholds of the test ear. If it effects the thresholds of the test ear it is called overmasking.

Thus the student should know minimum amount of masking noise needed to mask, and the maximum amount of masking noise he can use without the danger of over masklng or cross hearing.

Thus we have,

- minimum effective masking level in,
  - air conduction testing
  - bone conduction testing
  - speech reception threshold measurement

and

- maximum effective masking level in,

- air conduction
- bone conduction and
- speech reception measurements.

A number of factors are involved suchas, effective level of masking, air bone gap, occlusion effect, signal to noise ratio at the not-test ear, etc., in determining minimum and maximum effective level of masking noise. And factors involved in minimum effective level are diff-erent from factors invloved in maximum effective evel. 3o each of them is dealt spearately.

A) Minimum effective masking level (Main)

The minimum effective masking level is the minimim amount of noise in the non-tost ear which is just sufficient to mask a pure tone that might appear in the non-test ear because of cross hearing.

In short, the noise level just sufficient to mask the test signal in the ear to which noise is presented.

Thus in minimum effective masking level, noise from the earphone and test tone from the test ear are present in the non-test ear. and in test ear only test tone is present. Schematic diagram illustrates this, see figure number 18.

A.a. Calculation of minimum effective masking level in air conduction

The mlninum effective masking level in air conduction is determined by the following factors:

1. Level of the test tone reaching the cochlea of the non-test ear.

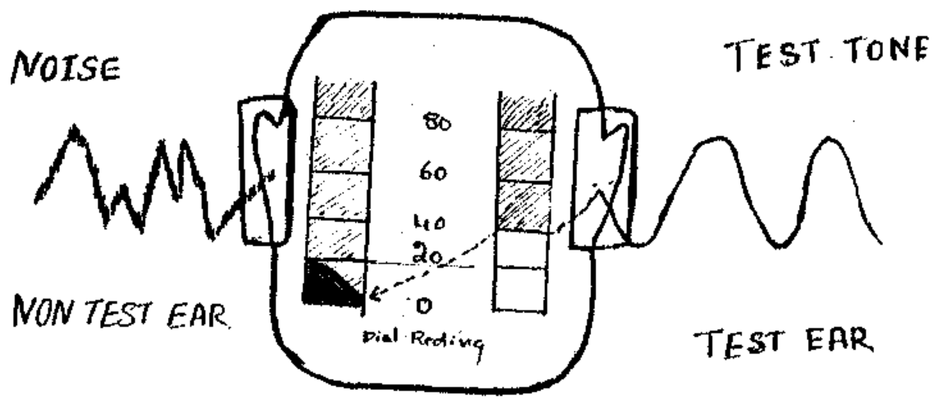


Fig. 18. Schematic diagram for minimum effective masking level.

2. Effective level of masking and
3. Air bone gap in the non-test ear.

We shall consider these factors one by one and finally arrive at the minimum effective masking level for air conduction.

1. Level of the test tone reaching the cochlea of.the non-test ear

The student might recall that level of the tone reaching the non-test ear is determined by two factors, that is presentation level of the test signal and initeraural attenuation. The level of the tone reaching the non-test ear is given by presentation level of the test signal minus interaural attenuation,

Symbolically,

PTL - IA = Test tone level in the non-test ear. . . . .(1)

2. Effective level of masking:

This is the noise level needed to mask a threshold tone or produce a threshold shift. This is because 0dBHL tone cannot be masked by 0dBSPL noise. For example when zero dBHL tone and zero 0BSPL noise are presented to the same ear, the tone is heard. The level of the masking noise must be increased to about 20dB hearing level before an appreciable shift in the pure tone threshold. Thus first 20dB increase of masking noise above pure tone threshold produces no masking. Thus the level of the noise just sufficient to mask a 0dB tone is called effective level of the noise. This is a property of the masking noise and varies with the frequency and the type of noise used (Staab,1975). This is also called as 'masking factor!

Rose (1978) calls it as minimum masking level and defines as the amount of noise needed to just mask a 0dB HTL tone.

At higher intensity levels (above 20dB), given dB increase in the level of masking results in approximately equal increase in the amount of masking or threshold shift of the test tone- thus presenting a linear relationship (Glorig,l966).
A glance at the table 2 makes this clear.

Thus the difference between two signals then remain constant for all higher noise levels.

Continuing with the same example i.e., figure number 19, 20dB is reaching the cochlea. Thus to mask this 20dB tone we have t0 give 40dB noise, i.e level of the tone in the non-test ear (20dB) plus masking factor (20dB). Thus symbolical

M min = PTL - IA + MF. . . . . (1+2)

Determination of effective masking level

There are two methods in determining effective masking level.

1. Through actual threshold measurement rnd
2. Through computation.

1. Through actual threshold measurement:

Studebaker's method (1967):

- first find out the threshold
- switch both the noise and pulsing pure tone signal

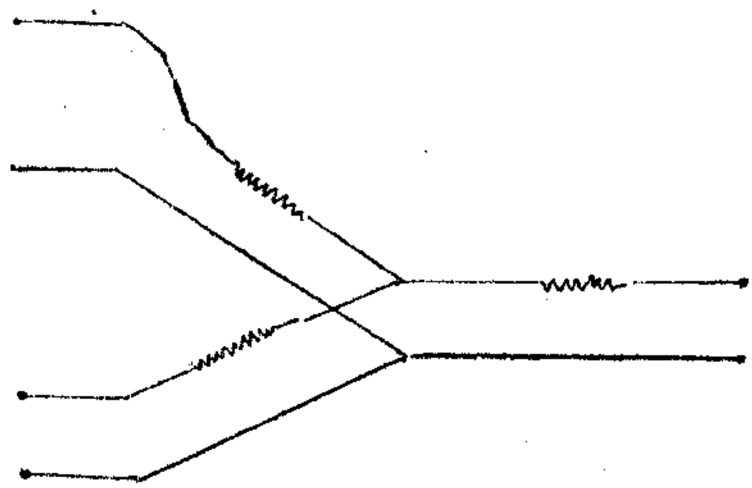
into the same ear and determine the threshold for the test tone on several subjects at several levels of masking noise.

Figure 20 shows a combining network for the purpose of directing test signal and masker to the same earphone. This network reduces the output of the earphone by 8 or 9dB. The reduction is equal for all frequencies and for both masker and test signal. The minimum masking levels obtained therefore undffected by the network (Studebrker, 1967). Modern clinical audiometers have this provision of directing both noise and signal to the same ear.

- Obtain a median value and plot as shown in the figure 21.
- Then draw a vertical line connecting the abcissa with the plotted line at a point where the plotted line approximates a 45 angle and then a horizontal line from this intersection to the oodinate.
- Plotted vertical line indicates the noise level and plotted horizontal line indicates threshold for pulsed tone.
- The difference between the two is minimum masking level, or effective level masking or masking factor. In the figure number 21 masking factor is 20dB.
- Process should be repeated for all the frequencies using different noises and test signal.

Table:2 showing the effects of masking facoor

To mask	Noise level required
Odp tone	20dB
20dB tone	20+20=40dB
30dB tone	30+20=50dB
40dB tone	40+20=60dB
50dB tone	50+20=70dB
60dB tone	60+20=80dB
7OdB tone	70+20=90dB



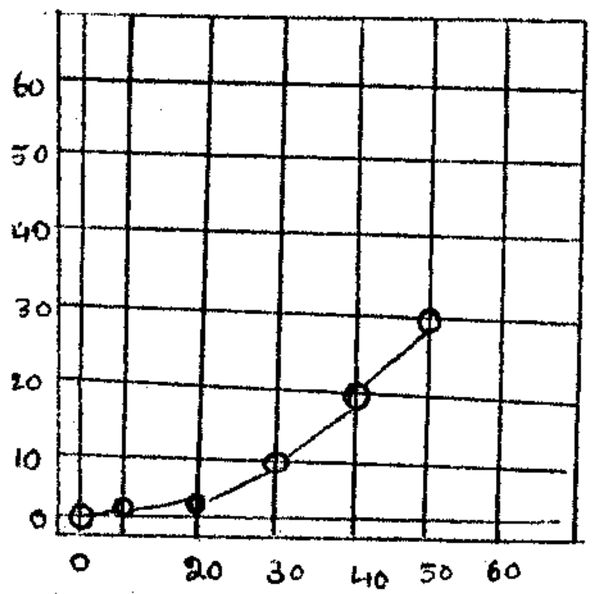


Figure:21 Illustration of plotting the median vnlue for effective maskinr level.

This is because (according to Menzel,1968) the amount by which the level of masking noise must exceed that of the tone in order tO mask it varies a great deal according to the qualitative aspects of both the noise and the tone.

Martin's mothod:

- Take reliable normal subjects.
- Present pure tone of 30dPHL into one ear and masking noise to same ear.
- Increase the noise intensity until the tone is just masked out.
- Then for each frequency, 30dB can be subtracted from each masking level and that level is regarded as masking factor.

Martin(l987) recommends that " these levels should be posted on the audiometer in the form of a correction chart."

These methods are not useful when audiometers do not have provision for mixing the tone and masking noise. For such a situation Menzel (1968) suggests to have group of listeners with severe or total unilateral sensori-neural hearing impairment.

2. Effedtive masking level by computation

1. Find out level per cycle (LPC) at different intensities of noise as mentioned elsewhere.
2. Now we can know the total energy in the critical band, if we know the width of the critical band.

The critical band widths from the data of Hawkins and Stevens (1950), as quoted by Senders (1978) are shown in the table 3.

Thus energy in the critical hand = level per cycle + 10 times the logarithms of the critical band width.

Symbolicaily,

$$ECP = EPC + 10 \log CBW.$$

- The difference between the value for energy in the critical band width and the level necessary to reach threshold at a given frequency is the effective level (Z) of the noise at that frequency. Thus effective level (Z) can be computed as follows:

$$Z = RPC + 10 \log CBW - \text{threshold in quiet(dBSPL)}$$

Worked Example:

To find out effective level of 60dP white noise in asking 500Hz tone.

- $LBC = 0ASPL - 10 \log CBW$

  $= 60 - 3.78 \times 10$

  $= 22.2$ dB

- Thus energy in each cycle of white noise while masking 500Hz pure tone is 22.2dB. The frequency band width at 500Hz is 50. Thus the total energy in the critical band would be 22.2 X 50. Converting it into logarithmi(value,

$$ECP = 22.2 + 17 \text{ by formula}$$

Table:3 showing critinal band width for eleven test frequencies. Hawkings and, Stevens data. From Sander's 1978 "asking", in Handbook of clinical. audiology,Katz,J.

Center Frequency	Critical In Hz	band width 10log CEW
125	70.8	18.5
250	50	17
500	50	17
750	56.2	17.5
1000	64	18
1500	79.4	10
2000	100	20
3000	158	22
4000	200	23
6000	376	25.76
8000	501	27

Table :4 Amount of noise in dBSPL required to mask od tones of various frequencies.

250	500	1000	2000	4000	8000	Noise
48	44	45	56		85	sew tocth
48	33	28	30	20	22	
					26	
32	17	14	18	14		nerrow band

Table :5 Showing the aproximate values of the occlusion effect reported by Zwislocki (1953).

250	500	1000	2000	4000
30	20	10	0	0

- Effective level of 60dB white noise is

$$Z = 22.2 + 17 - 11.5 \text{ by formula}$$
$$= 27.7$$

Thus 60dB white noise produces 27.7 dB threshold shift for 500Hz tone.

Similarly, find out effective level of 60dB narrow band noise at 500Hz.

Effective masking table:

Thus it is evident that whatever number appears in the audiometric masking dial cf the 'adiometev is meaningless unless it is calibrated in effective levels at each frequency. This has to oe done, though some audiometers have masking noise designed to be more nearly uniform in masking effective-noss for several test frequencies, owing to 'he differences of the ear's sensitivity for different frequencies.

Thus preparing a effective masking table provides the clinician with a predeter incd set of minimum masking leve s (masking factor).

Table 4 (page number 55) shows an approximation of the amount of noise in dB SPL required to mask odBTL tones of various frequencies.

3. <u>Air bone gap in the non-test_ear_</u>

The third and the final factor in determining the minimum effective level masking in air conduction is the air bona gap in the non-test ear.

Studebaker (1964) suggested that presence of air hone gap in the non-test ear change6 the signal (test tone) to noise (masking ratio. This is because the signal is heard by bone conduction, which is not affected, while the noise is being presented through air conduction which is affected. Thus 'ir bone gap in the non-test ear interferes with the level of nasking noise reaching the cochlea of the non-test ear. Thus if ""here is a air hone gap in the non-test ear, which brings about a change in the signal to noise ratio, is compensated by adding the amount of air bone gap to the level of the masking noise.

Thus minimum effective masking level is equal to level of the tone reaching the non-test ear plus effective level masking and plus air bone gap in the non-test ear ...

Symbolically,

M min. = PTL - IA + TF + (ACT - CT) ...1+2+3

A.b. Calcuation of minimum effective masking level in bone conduction

The minimum effective masking level in bone conduction is determined by the following factors:

1. level of the test tone reaching cochlea of the non-test ear.
2. effective level of masking
3. air bone gap in the non-test ear or occlusion eff

1. The level of the test tone reaching cochea is determin by presentation level minus the interaural attenuation.

Since interaural attenuation Tor bone conduction is generally consldered as zero see interaural attenuation) almost all the energy reaches the cochlea of the non-test ear. Thus energy present in the non-test ear is the presentation level at the test ear. Thus symbolically,

M min = PTL. + ... (1)

2. Effective_level_of masking

Same as in air conduction. This symbolically, it become

M min = PTL + MF -......... (2)

3. Air bone gap in the non-test ear.

Again as in air conduction. Thus symbolically, it becomes

M min = PTL + MF + (ACT - PCT] .... (3)

4. Occlusion effect (OE)

Let us take for example, a normal hearing person.. Take his unmaksed bone conduction threshold. Then occlude the ears and again take unmaksed bone coduction threshold. You will definitely see improvement in his bonp conduction threshold, for low frequencies. This improvement in bone cnnduction threshold due to occlusion of the ears is called occlusion effect. This is defined as " the increase in loudness far bone conducted stimuli when the ear canals are covered" (Rose,1978).

Explanation given for the occlusion effect are the following.

I. Mandibular inertia:

Condyle of the mandible articul tes with the skull. When the skull is vibrated during bone conduction the mandible which is loosely held to the skull, because of its inertia lags behind the skull. This movement relative to skull produces slight in and out of the canal wall, because of which there is change in air pressure within the canal. If the canal is,opened,changes in air pressure, escapes int" atmosphere (least resistance path). If covered, drum acts as a least resistance path air pressure changes are heard as air conducted sound. This was given by Bekesy (1941). However, Allen and Fernandez (1960), observed two patients each with the lower jaw missing on one side, in both of them the occlusion effect could be elicited in either ear at approximately the same magnitude.

2. Huizing (1960) emphasized the role of resonance in the external canal. The resonponce of the air within a tube is different when the tube is open and when it is closed. Thus, occluding the ear canal ought to shift it's resonance point.

Thus describing an underlying mechanism has been one of the most challenging problems of bone conduction theory (Tondorff,1972).

In occlusion effect, actually the bone conduction threshold does not improve but what realy happens is an increase in the level of the stimulus reaching the inner ear.

The most notable characteristic of occlusion effect is it's frequency dependencyof greater magnitude of the lower frequencies, (Liebman & Arasim,l97l). The occlusion effect changes, bone conduction measure by as much as 25 to 30dB in the low frequencies with continously less effect as frequency increases.

Table 5 shows (page number 55) the aptroximate values of the occlusion effect reported by Zwislocki (1953).

When masking is needed, the nontest ear is covered by an earphone, thuscreating occlusion effect in that ear. This enhances the strength of the test sjgnal reaching the non-test ear. This means that likelihood of the non-test ear responding to low frequencies presented to the test ear is increased. To overcome this, amount of masking noise in the non-test ear should he increased by the corresponding amount of occlusion effect.

Occlusion ef'ect should not be added in the following situations.

1. Air conduction testing:

Since both ears are covered at all times, an oce-Jusion effect is not created. When mnsking is introduced into the non-test ear.

2.When air bone gap is presnet in the non-test ear

This is because small changes in nir pressure in the external ear canal caused by the occlusion effect are not sufficiently intense to overcome the concductive component of the hearing loss (Rose,1978).

In other words conductive loss produces a built in occlusion effect (Studebaker,1962). Thus a minimum effective masking level becomes,

M min = PTL + MF + OE . . . .(4)

Thus minimum effective masking level for bone conduction is either

M min = PTL + MF + (ACT- PCT)
or
M min = PTL + MF + 0E

To find occlusion effect for the_individual under test

- Obtain unmsked bone conduction thresholds with both ears uncovered.
- Obtain unmasked bone conduction thresholds with non-test ear covered for lower frequencies and
- Subtract occluded thresholds from unoccluded threshold at each frequency.
- The difference is occlusion effect.

This method is an audiometric version of the Ring test described by Martin (1974). He recommends this procedure saying that " where increased maqsking is required to offset the effect of having occluded the masked ear, the precise amount of noise may be added rather than some average figure that may be more or less masking than required for the patient.

A.c. Calculation of minimum effective masking level in speech reception threshold measurement:

Until recent years, little has been written on the subject of masking for speech audiometry (Martin,1975). However the minimum effective masking level to rule out the the participation of the non-test ear in speech reception threshold measurement is determined by the same factors as in the case of air conduction pure tone testing.

Thus minimum effective masking level in speech reception threshold represented symbolically as follows.

M min = PTL +IA + MF + (ACT - PCT)

(Note: largest air bone gap should be added)

If we are finding out the speech reception threshold through bone conduction occlusion effect may or may not be added depending upon the presence or absence of air boae gap in the non-test ear. In such a situation the amount of occlusion effect would be (Martin,197), or the largest air bone gap.

Martin's method (1967) of Minimum masking

There are a number of masking methods in use for masking (Studebaker,1964; Liden,l959). The method so far we discussed is the Studebrker's (1964) method. Studebaker (1967) himself agrees that while these formulae are accurate, thev are time consuming and not always practical for clinical use. Martin (1967) has suggested that the formulae are actually unnecessary and all that is needed is to present to the non-test ear a level of effective masking equal to the air conduction threshold of the non-test ear.

Explanation:

A signal heard at threshold has a sensation level of 0dB. This is regardless of the subject's hearing level (HL), i.e whether 80dBHL or 30dPHL. Thus when we present tone to the poorer ear and if he responds, whether that is heard by poorer ear or the opposite ear sensation level is 0 dB. Let us assume the response as shadow response, Thus in order to rule out the participtíon of the better ear, is just to mask the tone of 0dBSL. 0dBSL tone is masked by 0dPSRL noise plus effective masking level or masking factor. In order to give 0dB noise, noise should be presented at the air conduction threshold level of the non-test ear. Air conduction threshold level also maintains signal/noise ratio (mentioned elsewhere in this project).

Thus the ?artin's (1967) formula reads, air conduction threshold of the non-test ear plus the masking "actor. symbolically,

$$M\ min = ACT_{NTE} + MF$$

Masking method for bone conduction sis very much the same as for air conduction. However, if there is no air bone gap, occlusion effect for the tested frequency must be added, therfore,

$$M\ min = ACT_{NTE} + ME + OE \quad (\text{ if no air bone gap})$$

Adding of the occlusion effect value may Lead to overmasking. In such a case it is better to use insert receivers. The increased interaural attenuation provided by these small phones decreases the probability of overmasking (Martin,1975).

Martin (1974) reviewing the minimum effective masking levels in threshold audiometry concludes that " it is advisible to add approximately l0dB of noise after calibration to account tor the inter subject variability with ecspect to the "effectiveness" of the effective masking level. And he calls this as safty factor___ Thus the formula reads,

$$M\ min = ACT_{NTE} + MF + SF$$

SafetY factor should be, added even for minimum effective masking level for hone conduction.

Liden's (1971) method for minimum effective mesking level

Minimum effective leve will be equal to the test ears air conduction threshod minus attenuation factor and the difference between the masked ears air conduction and bone conduction thresholds. Symbolically,

$$MEM = A_t - IA + (A_m - B_m)$$

Minimum effective masking level ( )for hone conducted signal is equal to the test ears bone conduction threshold (Pt) plus the difference between the masked cars air conduction and hone conduction thresholds. Symbolically,

$$FM = Bt + (Am - Bm)$$

Maximum effective masking level:

So far by calculating the minimum effective masking level needed to mask the test tone in the non-test ear, we have met the criterion of efficiencv. Now we shail take up criterion of repurcussion, which says that noise in the non-test ear should not affect the threshold of the test ear.

Unfortunately many a time the noise inthe non-test ear is high enough to lrteralize to test ear through bone conduction and there by affecting thresholds in the test ear. See transcranial masking (chapter number viii). Thus it is indis- pensable to find out the maximum amount of noise that can be used in the non-test ear without affecting the thresholds of the test par. Thus calculation of minimum effective & M max. masking is of equal importance to satisfy both the conditions of how much of masking. To quote aloyd (1978),

" Just as it is Important to determine what the minimum effective masking leve is to avoid underworking, it is equally important to determine what mximum level of m sklng can be used without overmasking."

Definition_Of maximum.effective masking level.

It is the highest level of noise that can he presented to one ear via an earphone before the noise crosses the skull and shifts the threshold of the opposite ear (Martin, 1975).

Calculation of maximum effective masking leyel_(M max)

" The maximum masking that can be used without affecting substantially the threshold of the tested ear depends on the attenuation of sound travelling from the one side to the other and on the bone conduction loss of the tested ear" (Studebaker,1962).

To understand this, concept of overmasking should be made clear.

Overmasking:

Masking noise is presented through an earphone (air conduction signal). This m sking signal should reach the opposite ear, should be more than 50dB, since minimum interaural attenuation for noise is 50dB (see interaural attenuation). Thus presentation level minus 50dB reaches the opposite ear. Let us say xdB. This xdB should be atieast little above or equal to the bone conduction threshold of the test ear, in order to mask the one in the test car. Thus ovormasking occurs when,

$$PTL - 5OdB \geq PCT\ BCT_{TE}$$

Even if the crossed signAL is 5 dB less than the bone conduction threshold of the test ear, overmasking will not occur. This principle is used in calculating maximum effective masking level.

$$M\ max. = IA\ (for\ noise) + BCT_{TB} - 5dB$$

Since we present the masking noise always through one earphone, irrespective of kind of testing (whether air conduction, bone conduction or speech reception threshold measurement, suprathreshold audiometry) the same formular holds good for all kinds of testlngq

Thus the meximum masking is the masker level which is just insufficient to mask the test signal in the test ear (Studebaker,1967).

Smith's method of masking

Owing to the difficulty in determining how much masking should be used at a particular frequency for a given patient Smith (1968) gave a new approach to clinical masking

Rationale of the Method:

It takes approximately the same level or intensity of narrow band noise to cross lateralize from the had ear to the good ear to the bad ear. That is the transmission loss across the skull is approximately the same ($\pm$ 5dB).

Technique:

-Establish the unmasked threshold of the test frequency in the good ear using an interrupted tone.

-Then present 5dBSL pulsed tone continuosly to the same ear. This is because tone should be clear to him and to compensate for central masking.

-Give narrow band noise to the poorer ear, preferably via insert receiver.

-Increase the level of masking noise in the poorer ear until the 5dB SL tone in the good ear is just audible.

-Note down the level of masking noise. Subtract 5dB from this level. This compensation for the 5dB added previou-sly in step 3.

-This value is the amount of narrow band noise that should be used in the good ear.

-Repeat this procedure for all test frequencies.

This amount of masking wou'd be appropriate in most instances for masking thegood ear while testing the poorer ear at that frequency.

Precautions.:

1. When there is large difference between ears the masking noise should be increased somewhat to verify the threshold and
2. As is true of all procedures an air hone gap in the better ear is still a big problem

Plateau seeking Method:

Hood (1960) first reported this techmique. This technique has been variously called such as, threshold shift procedure, shadowing method. This techniqu e is being used in. almost all clinics even today.

This method consists of the following steps:

- Whenever the danger of cross hearing is indicated (as mentioned elesewhere in the project), calculate minimum effective level masking and introduce noise to the better ear.
- Reestablish threshold in the test ear. If thereis no threshold shift, non-test ear is not participating. If there is a threshold shift note down the level at which the subject responds and the level of the noise and procede to the next step.
- Increase the noise level in the non-test ear by 5 or 10dB and again note down the level at which he responds and the level of the noise.

- The process should be reported, until the subject shows no further shifts with increase in noise in the better ear. Then the level of the noise can be increased several tines (20-30dB) without shifting the threshold in the test ear, the 'plateau' has been reached. The level at which plateau was reached is the threshold.
- Further increase in noise will shift the threshold again. This is due to overmasking.

Figure 22 illustrates the plateau method.

In the figure,

a) undermasking, i.e both tone and the noise are stimulating the non-test ear.
b) plateau i.e tone is stimulating test ear and noise stimulating the non-test ear.
c) overmasking, both noise and tone stimulating the test ear.

Problem of overmasking plague all the masking rethods including the plateau method (Martin,1975). Larger the air bone gap, the narrower the plateau and smaller the air bone gap, the broader the plateau.

Masked threshold:

Masked threshold is the actual threshold of the patient obtained by ruling out the participation of the non-test ear. Before plotting the masked threshold student should consider the following suggestions.

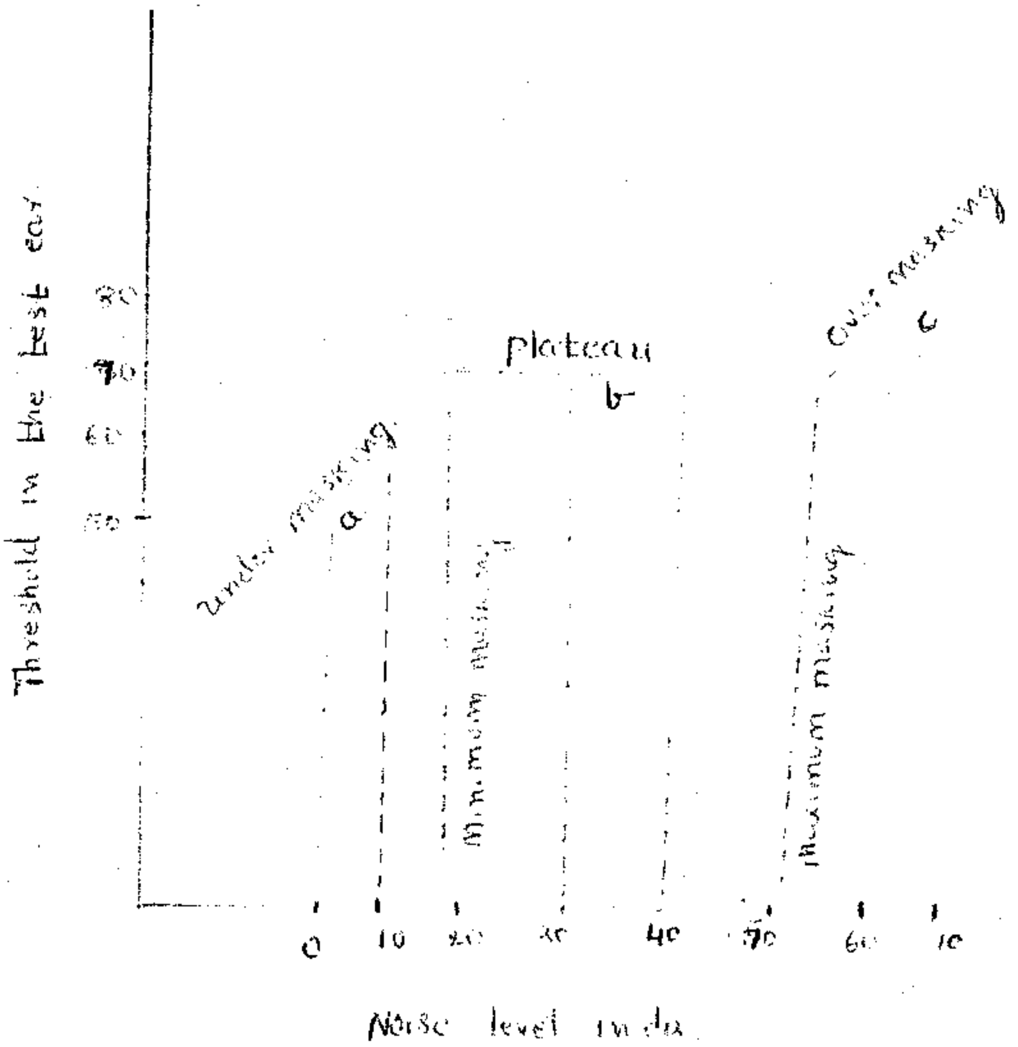
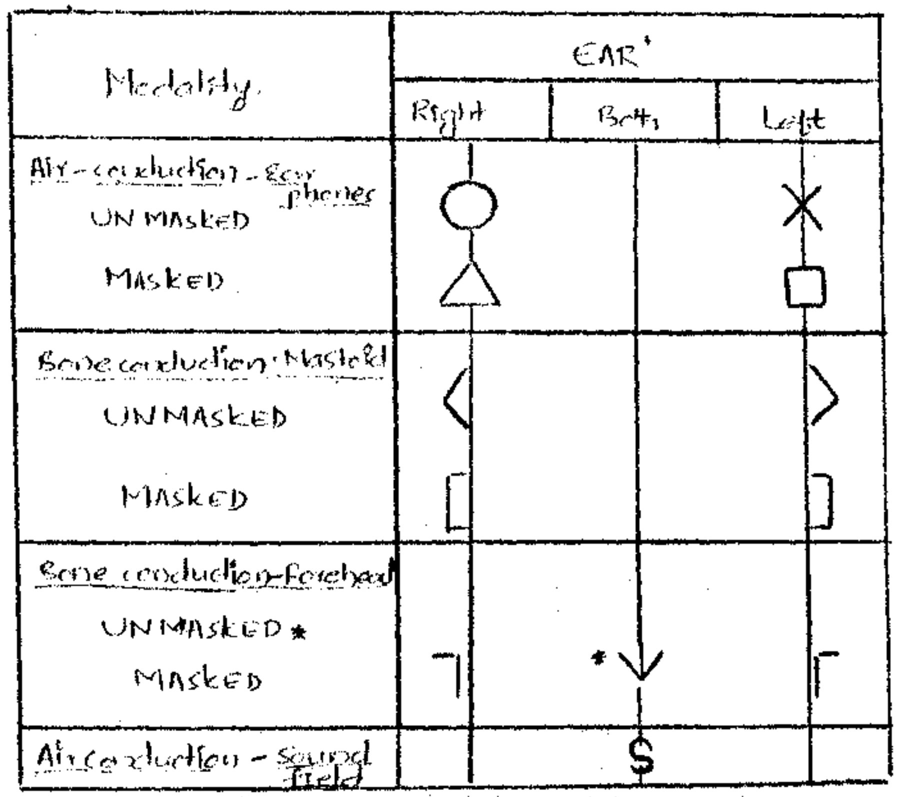
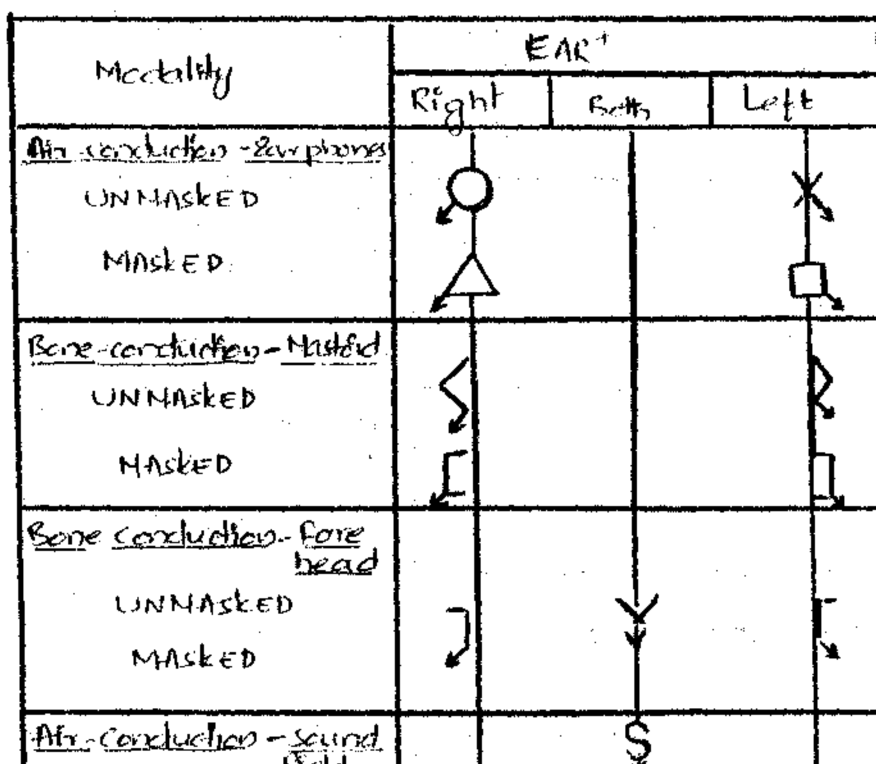


Figure 22 Illustration of the plateau method.

1. To use appropriate symbols to indicate air conduction, bone conduction with and without masking. Symbols are illustrated in the table 6. and
2. 5dB should be subtracted from the obtained threshold value due to central masking (see chapter viii).

Recomended Symbols for Threshold Audiometry (ANSI).
1974





Chapter VI

MASKING IN SUPRA- THRESHOLD AUDIOMETRY

WHEN AND HOW MUCH

Now we know when and how much should be masked in threshold audiometry. Let us now consider when and how masking shou d e done/performed in supra-threshold audiometry in this chapter.

When to mask:

In threshold audirmetry we said mask the opposite ear whenever the presentation level minurs the interaural attenuation value is higher or equal to the bone conduction threshold of the opposite ear at that respective frequency. We know in supra-threshold audiometry presentation levels are always higher. Thus it is evident that the level of the presentation vary often will exceed the bone conduction threshold of the non-test ear, by more than dB. Thus for practical reasons masking is always necessary in supra-threshold audiometry. Since the mechnnism of cross hearing is same even in supra-threshold audiometry,i.e, the rules for when to mask do not vary.

How much to mask:

As in the case of threshold audiometry, we have to satisfy the two criteriae. Thus accordingly we have to calculate minimum effective masking level and maximum effective masking level. Since same respective factors are

are involved in. minimum and maximum effective masking levels for suprathreshold audiometry as in the case of threshold audiometry, formulae do not vary.Explanations for these formula have been given earlier, hence here they are just symbolically represented under each conventional supra threshold test.

1. Masking in,speech discrimination testing

When:

$$PTL_{NTE} - IA \geq Test\ BCT$$

How much:

$$M\ min = FT - IA + MF + (ACT\ \ BCT)$$

$$M\ max = BCT_{CE} + IA - 5dB$$

As the frequency spectrum of speech covers A LARGE proportion of the audiorange a wide band noise is needed to mask it. Speech noise can also be used. One of these noise is a must.

While masking through insert rcciever interaurra1 attenuation for noise should be taken as 60dB instead of 50dP. See insert receiver (chapter IX)While calculating M max best be or average bone conduction should be taken into account. Care should be taken to not exceed patient's threshold of discomfort.

2. Masking in Increment Senitivity Index

There is considerable controversy in using contralateral. masking while administering SISI test, Blegrad Terki dsen (1967) showed that contralateral masking would improve the difference imen for intensity on the middle and high frequency range.

Osterhammel et.al (l969) while studying evoked responses to SISI stimuli with contralateral masking concluded that enhancement of 2,3 and 5dB increment occurs by the application of contralateral masking noise.

Plegrad (1969) tested the influence of contraterral masking on SISI scores in unilatera perceptive hearing loss cases. He found significant impruvement in the intensity discrimination at 1 and 4KHz. He concluded that with a few exception, the masking had no significance for the result of the topognostic SISI test usinG ldB increment.

Small (1961) while studing the testshold pen swings as a function of masker leve in the contralateral ear concluded that masker level had no significant effect.

Only further research mav help us in solving this problem whether to mask or not to mask. However. Martin (1975) suggests it is appropriate to mask during any auditory test when there is daner of cross hearing of the signal." Martin '1975) recommends the use of minimum masking in SISI test.

When to mask:

$$\text{SISI PTL} - \text{IA} \geq \text{BCT}_{NTE}$$

How AMUCH to_mask:

$$M\ min = \text{SISI PTL} - \text{IA} + (\text{ACT}-\text{PCT}) + \text{MF}$$

$$M\ max = \text{PCT}_{TE} + \text{IA} - 5\text{dB}$$

3. Masking in Tone-Decay test:

Masking of the non-test ear is necessary in tesing adaptation at threshold in many patients with uniateral heaing loss. Otherwise case of a presence of tone decay may give moderate tone decay, or negative tone decay.

But masking of the non t-test ear is found to have some influence on tone decay. For example Blegrad (1967) noted wider spparation of the Bekesy tracings with contra-lateral masking which was frequency dependent. Snashall (1974) also obtained similar results. Howver, it is appropriate to mask during my ruditory test when there is a danger of cross hearing (Martin,1978).

Plegard Josephson (1971), as quoted by Sn shall. (1974) have recommedned that contrclateral masking should always be sued with tone decay tests in order to avoid false negative results. Snashall (l974) prefers to mask tone decny test as little as possible to avoid unnecessary alarms due to false positive results. However, artin(l978) advocates not to use minimum masking since the level of the signal may be constantly increased during a threshold tone decay test.

The effect of contralateral masking was greatest for the most sensitive tests of tone decay (Snashall,1974).

WHen to mask:

$PTL - IA \geq BCT_{NTE}$.

How much msking:

M min = TDT PTL - IA + MF + (ACT - BCT)

M max = BCT $_{TB}$ +IA -5dB

Mechanism of masking effects:

1. It could be argued that cross masking occured with higher level of masking used there by increasing the amount of tone decav.
2. Another possibility is that the toe decay assessment without masking was due 'o cross hearing. It is possible with interanra' difference of 2dB.

4. Masking in Bekesy audiometry:

" One of the chief fields of application of Bakesy audiometer is and alwys seen differential diagnosis in cochlear and retrococh car esions, fact which is of the greatest actuality in patients with unilateral perceptive hearing loss." (PlegVad,1968).

Thus danger of cross hearing is more likeiy, and almost nefessiates contralateral masking in almost all situations. Unfortun-tely till now masking problem in Bekesy audiometry is unresolved.

This problem exists mainly because of two reasons.

1. Because of re ative changes in the audiogams due to contra ateral masking, (1968) reports following changes in audiogram with contra ateral masking.
   a. the masking noise is found to incye se the sooaration between interrupted and continous tone.

b. marked reduction in the tracing amplitude of fixed. frequency in continuous tractings.

c. normal individual changes from type to type IV patterns. In some patients changes from type II to type IV can lso occur.

And he concluded that the resu t is derisively influenced by the masking delivered' to the non-test ear.

Young (1968) while studying ippialteral masking effects concluded that amplitude were not effected by masking intensity level and by different masking stimuli .

2. The amount of contrlaterstion masking to be used in Bekesy -udiometry is more difficult to define than for other procedures, since the signal is not onlv changing in intensity but in frequency as well (Martin,1975).

However following clinical masking methods are being tried.

1. using maximum masking method (Martin,1976)
2. using 80dBSPL white noise irrespective of whatever the hearing threshold of the better ear (Blegvad, 1968) and
3. automatic masking procedure: In this procedure noise is presented to the non-test ear automatically. The noise level is coupled to the test signal attenuator so that the noise level at the non-test ear is always just above the test signal attenuator,

minus the interaural attenuation plus the occlusion effect. The clinician has to use a secondary attenuator in order to increase the noise level above this value when an air bone gap is present in the masked ear.

Chapter VII

MASKING IN EVOKED RES NSE AUDIOMETRY

As is the case in subjective audiometry bone conduction tones can be cross heard at a value as low as 0 to 5dB- influencing the evoked potential of theside under examination. This disturbing effect cannot be eliminated by leading the acoustic evoked potentltals from the contraloteral cerebral hemisphere. The patient with unilateral deafness showed no difference in charpcterisitcs between ipsilateral and contraltcral stimulation by hone conduction. The only way to avoid cross hearing is tusking the opposite ear just as in subjective audiometry (Freigang et.al,1974). Their studv also indicated that examination of the shadow curves for patients with unllateral deafness by means of evoked response audiometry showed, same values as by subjective audiometry. This suggest that the yules of masking common in conventional threshold audiometry should be used in evoked response audiometry to eliminate cooss hearing.

Thus mask the opposite ear when the presentation level of theclick minus the interaural attenuation is equal or greater than the bone conduction threshold of the opposite ear. Symbolically,

Mask when;

PTL(of clicks) - IA (for Clicks) $\geq BCT_{NTE}$ (for clicks)

How much

M min = PTL (fof click) -IA(fcr clicks) + air bone gap + MF.

M max = IA (for clicks) + BCT_{NTE} -5dB

When we give noise to the non-test ear and clicks to the test ear, in evoked response fudiometry student may get a doubt that noise will influence the Cortical evoked potential there by affecting the test result. But this is not the case. Hraden (1972) while studying the masking noise and it's effect upon the human cortical evoked potential concluded that " with binarual stimulation the brain responds only to the distinct clear cut stimulus more or less ignoring the steady state masking noise even at a higher intensity level. Thus continous masking noise will be effective centrally and seem to have no influence upon the summation of the human cortical evoked potential.

Masking in electrocochleography

Masking in electrocochleography is not necessarv though cross hearing occurs, because of the following reasons.

1. Since the clicks are presented through loud speaker in a sound field situation (Aran,1971) rnd
2. Action potential is peripheral neural response of the cochlear nerve, which in a practical sense, would not be subject to the influence of central activity, and is independent of the opposite ear (Yoshie,1973).

Chapter VIII

WHAT ARE THE TYPES OF MASKING

1. Central_masking:

In the very first chapter we learnt that masking is an ipsilateral phenomenon. From this concept we understood that mrasker can exert masking effect, on the maskee only if bothe masker and maskee are resented to the same ear. The exception to this is the central msking.

Let us take for example a normal person having OdP thresholds in both the ears. And when a low level of masker of insufficient intensity to cross the skull to the opposite ear is introduced into one ear, it tends to produce a small threshold shift in the other ear. This threshold shfit is called " centraL masking."

Central masking occurS when the test sound is presented to one ear and masking sound to the other ear. Central masking is a very smaller effect when compared to Monaural masking. Different authors have got different amount o" threshold shifts due to central masking. However Martin(l975) states that the threshold shift averages about 5dB. The amount of threshold shift increase with,

- the intensity of the masker (Studebaker,l962)
- the increase in frequency of the test tone Snyder, 1973) and
- the decrease in masker band width (Snyder,1973).

Wegel & Lane (1924) were among the first investigators to report changes in thresholds in the test ear when a masking tone was delivered sumultaneously to the non-test ear at low intensity levels. Since then many -uthors have studied about the phenomenon and have contributed to the knowledge of central masking. Osterhammel (1969) studied ther phenomenon objectively through evoked cortical responses. In his experiment 5dB incriments over the continous tone at rhreshoid, in the presence of contralateral masking noise did not brina any chnge in evoked cortical responses and thus giving on objective evidcnce for central masking.

This elevation in threshold may be because of

1. districting effect, however, " most investigators tend to peject any distracting effect of the masking noise as a factor in central masking" 'Menzel,l968).
2. Inhibition that is sent down from the auditory centres in the brain and has therefore been called " central masking" (Martin,1975) and,
3. When a fairly high masking level is presented, it nay activate the middle earmmuscles resulting in a resulting in a shift in the threshold in both ears even though only one ear is exposed to masking noise (Menzel,1968).

Out of these 3 explanation the second explanation is widely accepted.

Clinical application

" Central masking may never become a routine clinical tool because of the smallness of the threshold shifts it produces. Nevertheless it could play a role in clinical research aiming at understanding of neural pathologies" (Zwislocki,1971).

According to Menzel (1968), the error that is likely to result by ignoring the central masking phenomenon is not likely to charge, however Martin (1975) suggest, 5dP shou d be subtracted from the threshold values obtained to commensate for central masking. and he recommends this for both pure tone threshold and speech reception threshold.

Menzel (1968) suggest the following technique. If there is a suspicion that the central masking effect is unusually large,

1. mask the poorer ear and reestablish thresholds for the better ear. Naturally the thresholds should not be shifted. If they are then the extent of such shift should be an indication of central masking factor.
2. modified Rainvaille technique.

2. Remote masking:

Remote masking describes threshold shifts in the same ear produced by masker in a different frequency region from that of maskee,(Ward,1966). For example the masking produced in low frequency regions by high frequencies.

There are two theories to explain this phenomenon:

1. Remote masking results from usymmetrical mechanical action in the inner ear that generates broad band noise within the inner ear. The brord brnd noise is said to mask tones at frequencies remote from and below the narrow band masker.
2. Remote masking is the result of attenuation provided by the acoustic reflex.

Karlovich & Osier (1977) concluded that two tone complexes adds support to the hypothesis that remote masking is primarily a result of aural distortion, i.e unsymnetrical mechanicsl action in.the inner ear.

Keith & Anderson (1969), while investigating remote masking with cochlear impairment, concluded thrt dual mechanism of middle ear plus inner ear activity is a more suitable explanation of remote masking than ither theory alone.

Clinical application:

" Remote masking values indeed reduced symmetrically in bothe ears and progressively as a result of aging. Thus remote masking demonstrates the existence of cochlear conductive presbycusis and can be considered as a useful test of stiffness of the cochlear partition.

Transcranlal Masking:

Transcranial masking comes -bout because the ears connot be completely insulated from each other acoustically. The masker of sufficient intensity leaks around the head and produces masking in the opposite ear ("Ward,1968).

Transcranial masking' is a contralateral phenonmenon, in the same masker is in one ear, the Maskee in the other. They may be either direct or remote depending upon the frequencies of the masker and maskee. Transcranial masking will behave just like ipsilateral masking except that a higher level will regressed to produce any "effect at all.

Clinical application

Transcranial masking or cross masking clinically helps in limlting the audiologist to use appropriate level of maximum masking but not bevond that level.

Ipsilateral masking:

In ipsilatera1 masking the test tone and the Masking signal are presented in the same ear.

Clinical application:

Ipsilateral rasking phenomenon is widely used in clinical situations to calaulate the effective level of masking noises.

Chapter IX

PROBLEMS IN MASHING

1. Masking in children:

The child who has grown up and can follow instruction will not pose any problem to the clinician, but the younger child does.

This is especially true in the case of difficult-to-test. To quote " Audiologist has been often unsucessful in his attempts to obtain threshold data in difficult-to-test" (Lloyd et.a1.,1968).

Lloyd et.al. (1968) have described a TROCA procedure, by which they could successfully get masked threholds, in cases with unilateral hearing loss.

The procdure is as follows:

The procedure consists of 3 phases.

1. Establishing stimulus control inqulet. This is done by,
   - -determining reinforcers.
   - -establishing response to discriminative stimulus using operant conditioning
   - -stimulus generalization in terns of frequency and intensity
   - -if the child does not wear earphone, authors sugggst to employ time out.
2. Establishing stimulus control in background noise(white)
   - -same procedure as above.
3. Once this stimulus control is established in background

noise condition, masked thresholds can be obt ined using empirical methods of clinica1 Masking.

2. Nauntpn's Dilemma

The clinicnt adiologist is often confronted with a rather frustrating situation in most cases of moderately severe bilateral conductive hearing loss cases,(Naunton, 1960). This is because there is a definite need for de- quate rasking, but it is virtually impossible to adequately mask with conventional earphones. This is illustrated in the following example.

	Right ear	Left ear
ACT	50dB	5OdB
PCT	?	dB

In this case we cannot get true threshold of the right ear becausd for both air conduction and bone conduction tesing minimum masking is equals to maximum masking.

AC Min = 50 - 40 + 50

= 60dB

PC Min = 0+ 50

=50dB

Maximum masking = 0 + 50dB = 50dB.

Explanation

1. A marked air bone gap in the non-test ear increases the minimum effective level masking and does not alter the maximum permissible level.

2. A marked air bone gap in the test ear reduces the

test signal level, but not the noise level at the test cochlear Therefore maximum permissible level is decreased.

In other words minimum masking level increase and maximum Masking leval decreases resulting in subjects with moderately Severe conductive hearing loss in both ears or whenever the air bone gap exceeds the value of interaural attenuation.

This probler can be solved in two ways.

1. Using an jnsert receiver:

Use of insert receiver increases the interaural attenuation value for noise there by increasing the maximum permissible noise. Thus

M x= 0+70 (interaural attenuation for insert reveiver).

Thus max is more than M min, so masking can be done.

2.Using ipsilateral reflex: as suggested by Vynsamurthy (1980). If ipsilrteral reflex is present in the right ear, it is sensori-neural loss. Thus bone conduction is equals to air conduction i.e. air conduction threshold is 50dB and bone conduction threshold is 50dB. (In sensori-neural loss air conduction threshold is equals to bone conduction threshold). Now M min is less than M X therefore masking should help this case.

But cannot find the true bone condulation threshold.

produced in low frequency regions by big'- frequencies.

There are two theories to explain this phenomenon:

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Transcranial masking is a contralateral phenonmenon, in the same masker is in one ear, the maskee in the other. They may be either direct or remote depending upon the feequencies of the masker and maskee. Transcranial masking will behave just like ipsilateral masking except that a higher level will regressed to produce any aeffect at all.

Clinical application

Transcranial masking or cross masking clinically helps in limiting the audiologist to use appropriate level of maximum masking but not beyond that level.

Ipsilateral masking:

In ipsilrteral masking the test tone and the masking signal are presented in the same ear.

Clinical application:

Ipsilateral masking phenomenon is widely used in clinical situations to calaulate the effective level of masking noises.

Chapter Ix !

PROBLEMS IN MASKING

1. Masking_in children:

The child who has grown up and can follow instruction will not pose any problem to the clinician, but the younger child does.

This is especially true in the case of difficult-to-test. To quote " Audiologist has been often unsucessful in his attempts to obtain threshold data in difficult-to-test" (Lloyd et.al.,1968).

Lloyd et.al. (1968) have described a TROCA procedure, by which they could sucessfully get masked thresholds, in cases with unilateral hearing loss.

The produre_is as follows :

The procedure consists of 3 phases.

1. Establishing stimulus control inquiet. This is done by,
   - -determining reinforcers.
   - -establishing response to discrimintive stimulus using operant conditioning
   - -stimulus generalization in terms of frequency and intensity
   - -if the child does not wear earphone, authors sugggst to employ time out.
2. Establishing stimulus control in background noise(white
   - -same procedure as above.
3. Once this stimulus control is established in background

noise condition, masked thresholds can be obtained using empirical methods of clinical masking.

2. Naunton's Dilemma

The clinical audiologist is often confronted with a rather frustrating situation in most cases of moderately severe bilateral conductive hearing loss cases,(Naunton, 1960). This is because there is a definite need for de-quate masking, but it is virtually impossible to rdequately mask with conventional earphones. This is illustrated in the following example.

	Right ear	Left ear
ACT	50dB	50dB
PCT	? .	dB

In this case we cannot get true threshold of the right ear becausd for both air conduction and bone conduction tesing minimum masking is equals to maximum masking.

AC Min = 50 - 40 + 50

= 60dB

PC Min = 0+ 50

=50dB

Maximum masking = 0 + 50dB = 50dB.

Explanation

1. A marked air hone gap in the non-test ear increases the minimum effective level masking and does not alte the maximum permissible level.

2. A marked air bone gap in the test ear reduces the

test signal level, but not the noise level at the test cochlenx. Therefore maximum permissible level is decreased.

In other words minimum masking level increases and maximum masking level decreases resulting in subjects with moderately severe conductive hearing loss in both ears or whenever the air bone gap exceeds the value of interaural attenuation.

This problem can be solved in two ways.

1. Using an insert receiver:

Use of insert receiver increases the interaural attenuation value for noise there by increasing the maximum permissible noise. Thus

M max = 0+70 (interaural attenuation for insert receiver).

Thus M max is more than M min, so masking can be done.

2. Using ipsilateral reflex: as suggsted be Vyasamurthy (1980). If ipsilateral reflex is present in the right car, it is sehsori-neural loss. Thus bone conduction is equals to air conduction i.e. air conduction threshold is 50dB and bone conduction threshold is 50dB (In sensori-neural loss air conduction threshold is equals to bone conduction threshold). Now M Min is less than Mmix therefore masking should help this case.

But cannot find the true bone conducation threshold.

This is illustrated below.

M min =50 + 50 = 100

M max =50 + 50 = 100

At this point vyrsamurthy (1989) suggests a general rule.

"If an unmasked audiogram shows bilateral moderate/ moderately severe/severe hearing loss with normal bone conduction thresholds or significant air bone gap with affected bone conduction thresholds and if one of the ear is found to be sensori-neural loss through impedance audiometrv, the true bone conduction thresholds of the sensorineural hearing 1oss can be determined by masking the non-test ear provided the air bone gap of the non-test ear does not exceed 30dB."

Thus in ourexample,

If we reduce the air bone gap to 30dB the minimum masking: noise decreases to 80dB, and maximum noise level remains same. Since there is difference of 20dB, between two extreme value, one can get the plateau, and establish the threshold.

Finally this problem can also be solved by using inser receiver, which increases the maximum noise level to 120dB (Note: This holds good if only the audiometric noise output is 120dB).

Insert Receivers:

In a Naunton's dilemma case we learnt that, there is an indispensable need to increase the interaural nttenuation (for noise) to establish the actual thresholds.

And we know from the report of Zwislocki(l953), that highest interaural attenuation was given by the transducer with an insert plug. He observed that interpural attenuation for three earphones correspond inversly to the ratios of head areas exposed to sound prossure. Thus interaual attenuation is dpendent on the type of transducer used.

'The obvious so ution, therefore is to a smaller transducer, that is one which provides more interaural attenuation.

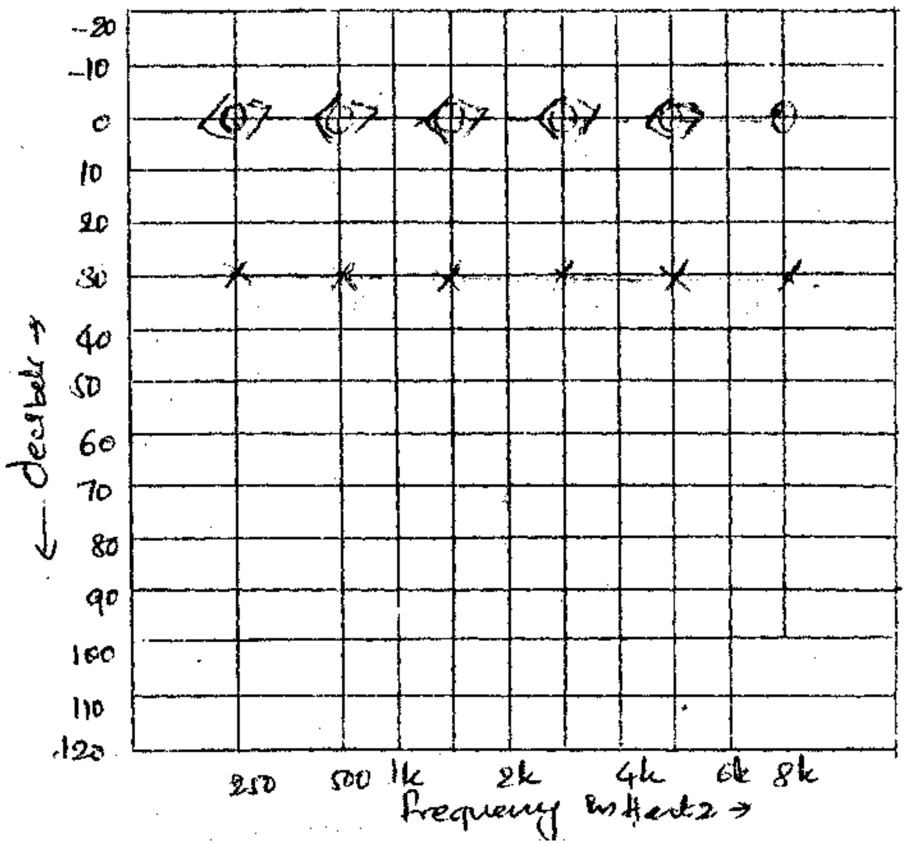
In the paSt, thecommon hearing aid type of inserts have been used, to increase the amount of interaural attenuation. However Lescouflair (19741 recommended not to use common hearing aid type ofinsert receiver because of following reasons:

1. Firstly, large differences of interanral attenuation are found by different authors.
2. Secondly, in clinical use the iasert earphone for e-ch patient and trying to fit it for various ear canal sizes is not particularly agreeable choice.
3. Changes in sound pressure at the ear occur due to variation in insertion and pressure.Consequently great caution in their use for masking is recommended. Finally it is the difficulty of adequately calibrating to obtain known masking levels at different frequencie

By observing above difficulties escouflair (l974) devised a masking transducer. He reported interaural attenuation of the new device to exceed by 25-30dB over the supra and al earphones and 16-34dB better than hearing aid type of receivers, and more reliable. The more he recommends it as a supplimenting tool to the clinician for masking in all cases, where other types of transducers are inadequate.

1. Does the audiogram show cross hearing for air conduction? Explain

2. Does the audiogram show cross hearing for hone conduction? Explain.

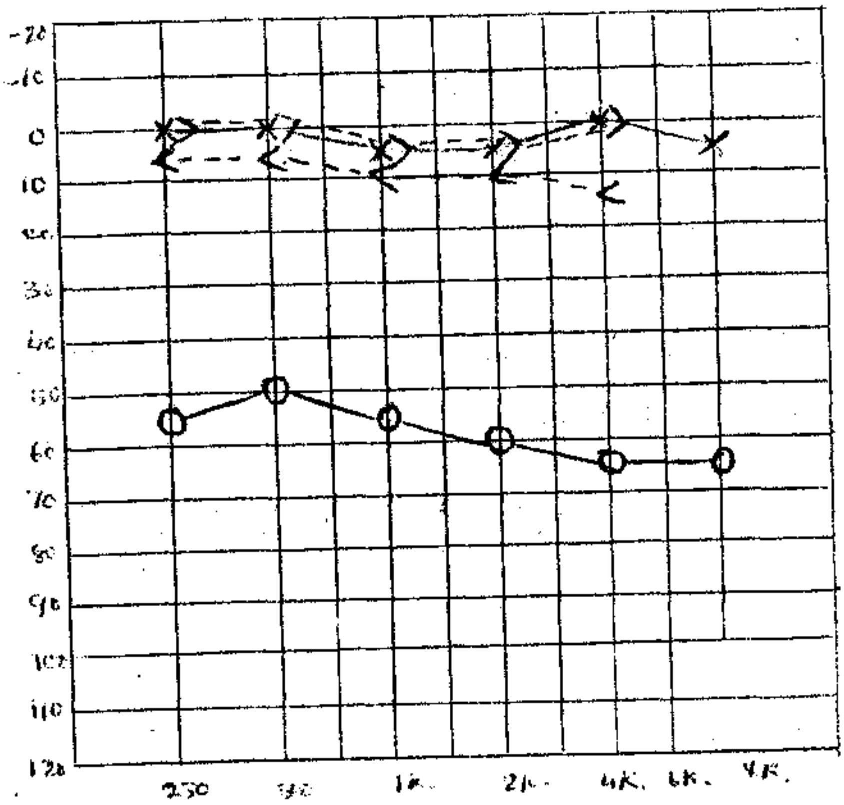


Answer: 1. No, because difference between left air conduction threshold and right bone conduction threshold is not more than 40dB.

2. Yest since interaur 1 atenuatlon for bone conduction is zwro, left bone conduction response could be the response of the tight cochlea.

1. What do the right unmasked thresholds represent?

2. To obt in the actual threshold which ear should be masked?



Answers :1. Shalow responses use denger of cross hearing is indicated

2. Always better ear should be masked. Hence,here left e r should be masked.

3. Rt. Conductive hearing loss.
   Rt. Mixed hearing loss
   Rt. total loss.

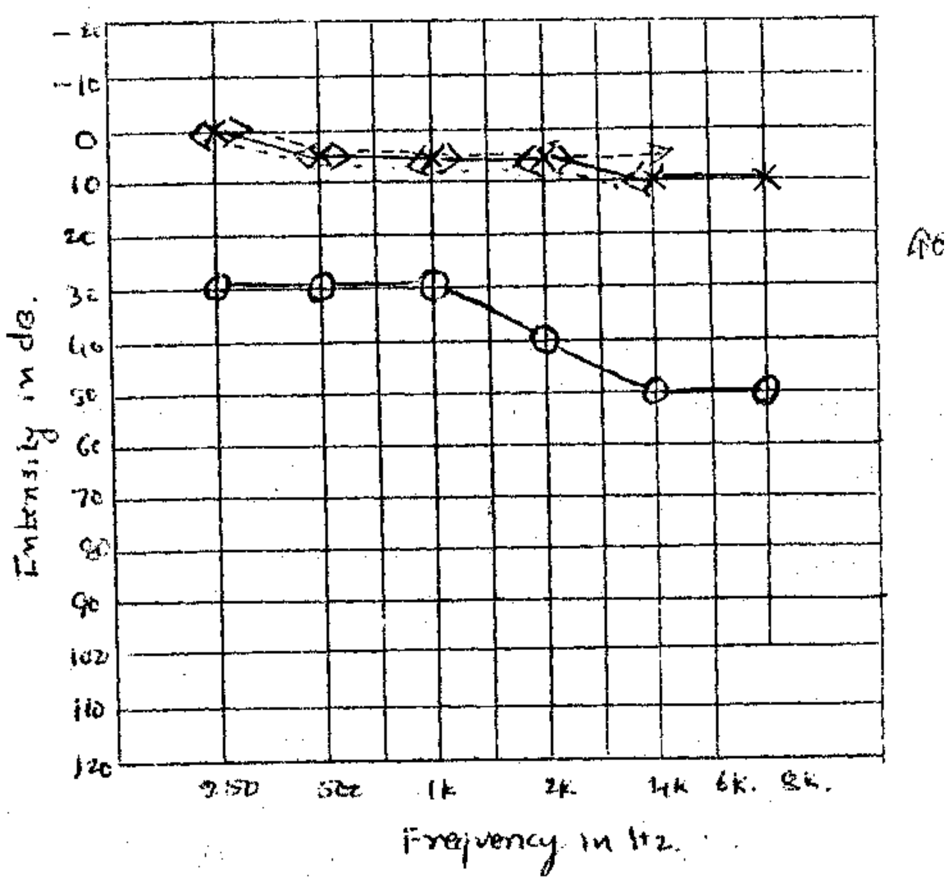
1. Is there a need for masking Explain.

2. In which ear masking noise should he delivered?

3. Calculate the amount of noise to he delivered for air conduction testing (in effective level).

4. Calcualte the amount of noise to be deliverd during bone conduction testing (ineffective Level).

5.



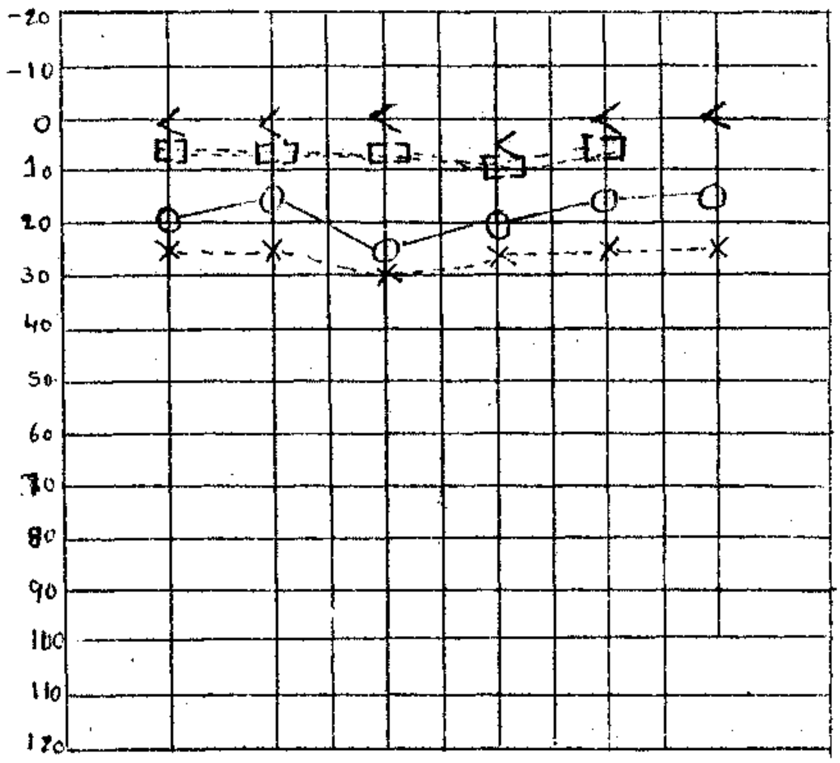
Answers:1. Yes msking is necessary during air ponduction testing only,at 4KHz, because danger of cross hearing is indicated. And in bone conductrin testing a
2.Left ear shold be masked.

3)At zk 20 dB. at 41.30dB at 8k 30dB.

4).At250 50dB,At 500 45Db,al 1k 35dB,al 2k 25dB,cl-4

1. Shy were bone conduction thresholds only masked?

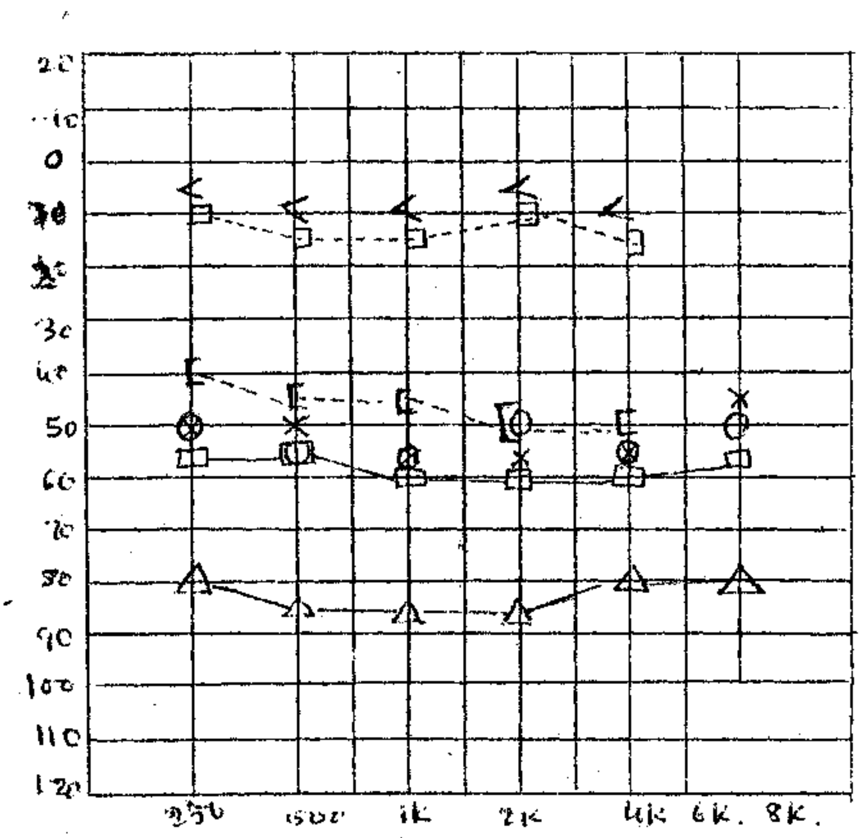
2. Is thre a necessity to apply masking during aer corduction testing?



Answers: 1. Yes, there is a necessity, air one gap exist in both ears.

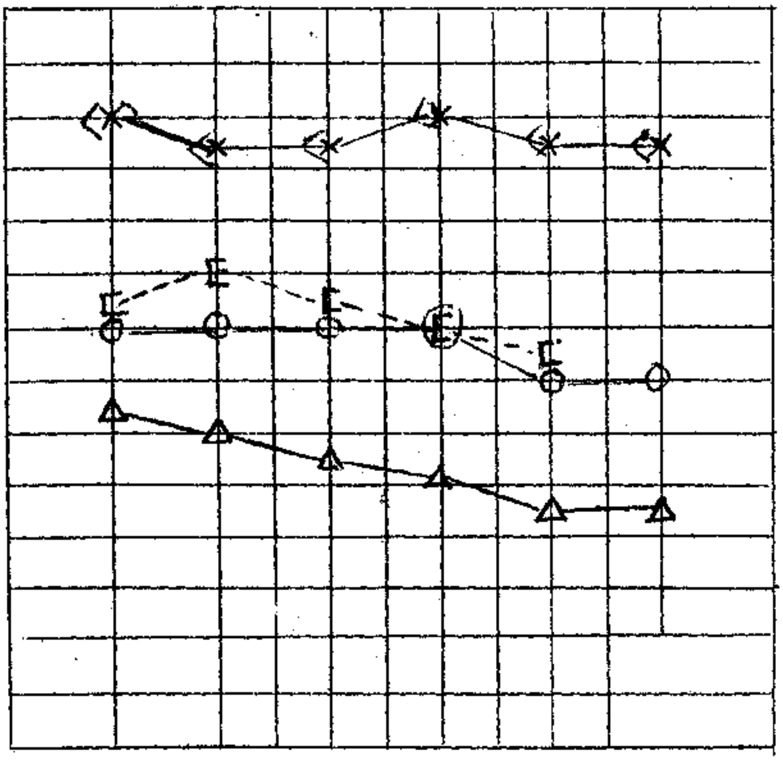
2. Not necessary to apply masking during air condutction testing because, difference between air conduction thresholds and bone conduction thresholds of the opposite ear does not amount to40dB

1. Is there any fault in plotting the audiogram?



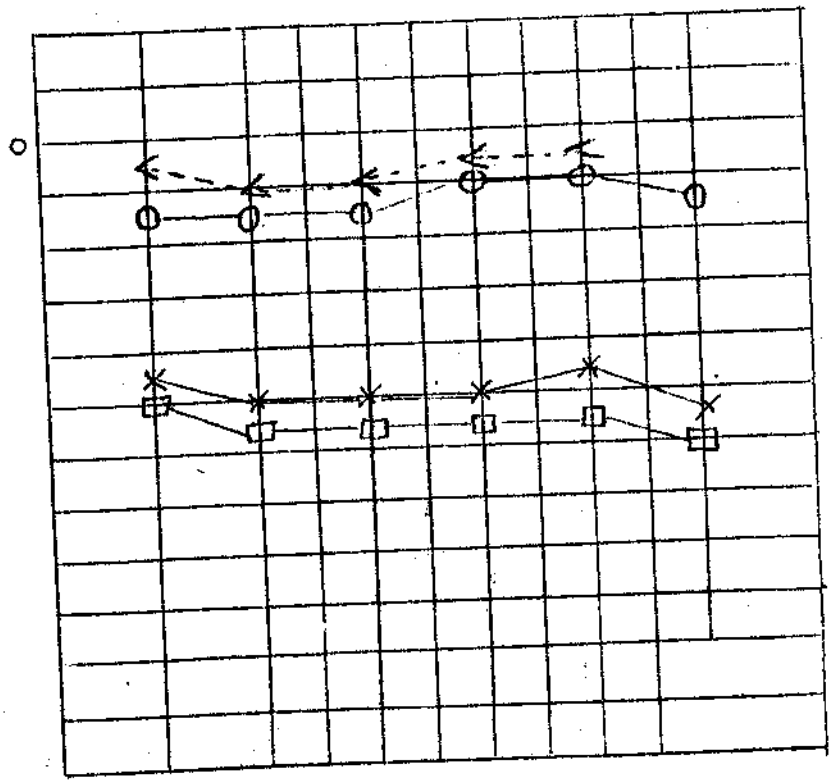
Answer: 1. Nothing wrong, approprjate symbols have been used.

1. Comment on 'he unmasked and masked results?



Answer: 1. Audiogram showing right conddctive loss
when masKing was not applied to better ear (left
ear. With the masking noise to the left
left ear, audiometric, pattern/into right /changed
mixed loss.

1. How do masked thresholds differ from unmasked threshold?
2. Is threshold shift significant?
3. What is your next test?



A nswer: 1. Masked thresholds differs from unmmasksed threshold by 5dB.This could be due to central masking

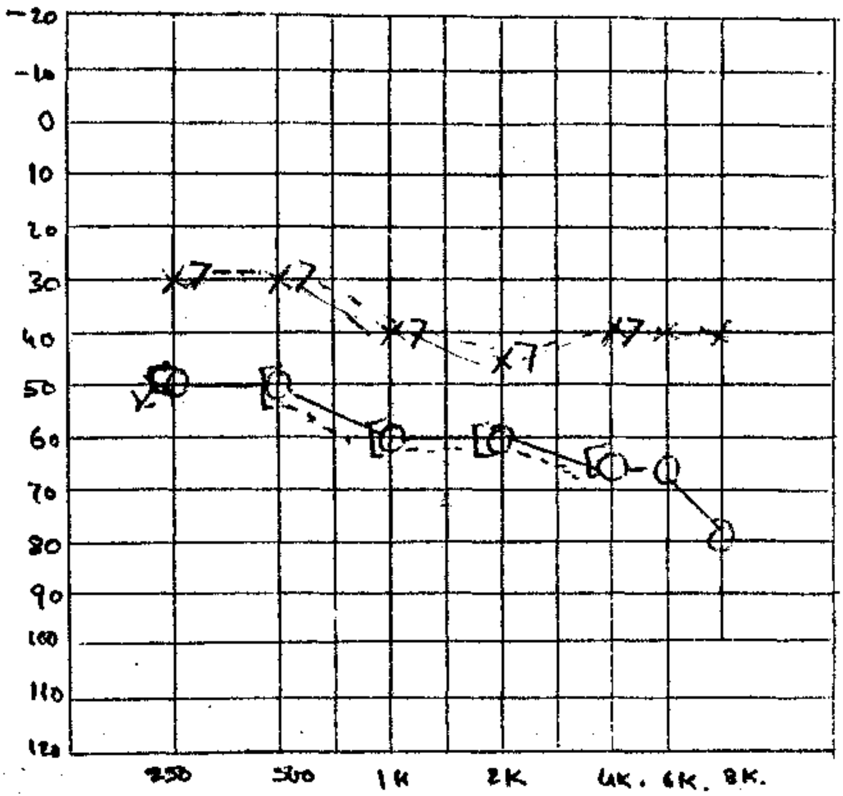
2. No.

3. To get masked bone conduction threshold of the left ear.

1. Why was masking noise presented to the left ear when the speech reception threshold was abtained in the right ear?

2.Why was masking noise app ied to obtain discrimination score in the right ear?

3.



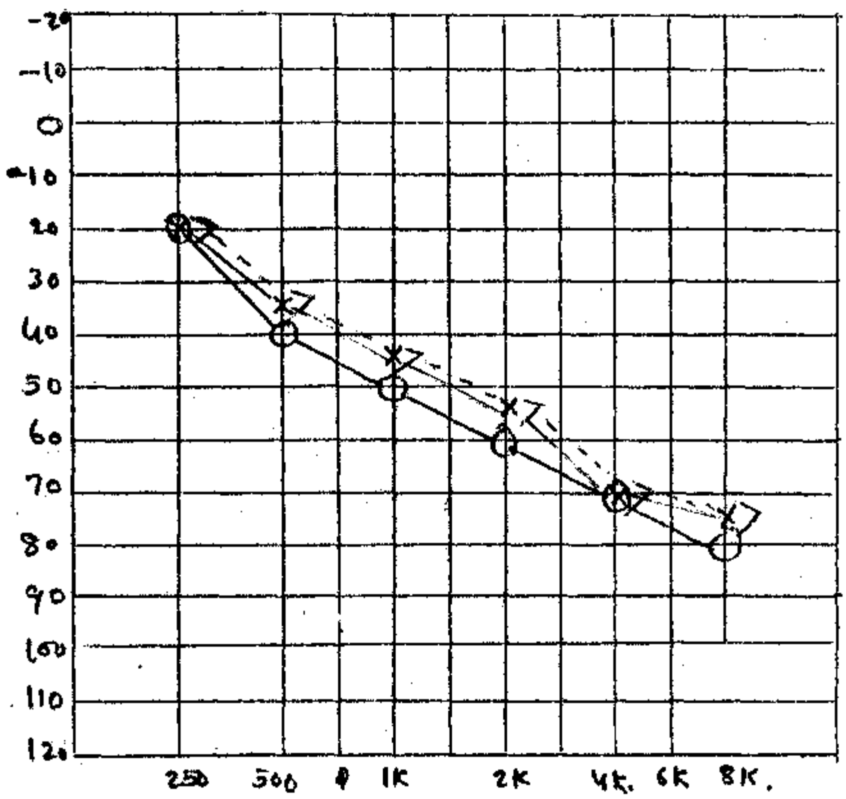
	SRT	SD.
Rt	55dB	90
left	35dB.	80.

1. Masking is not necessary because the difference between SRT of the right ear and best bone conduction threshold of the

2. Since presentation evel was increased by 40dB. danger of cross hearing is indicated, So masking was applied.

1. Is masking needed? explain.

2. While administering STAT, how much noise should be delivered to the non test ear?



Answer: 1. No, when no significant air bone gap exists in a bilateral symmetrica1 loss bne conduction can be tested from one mastoid cnly and without maSKing.

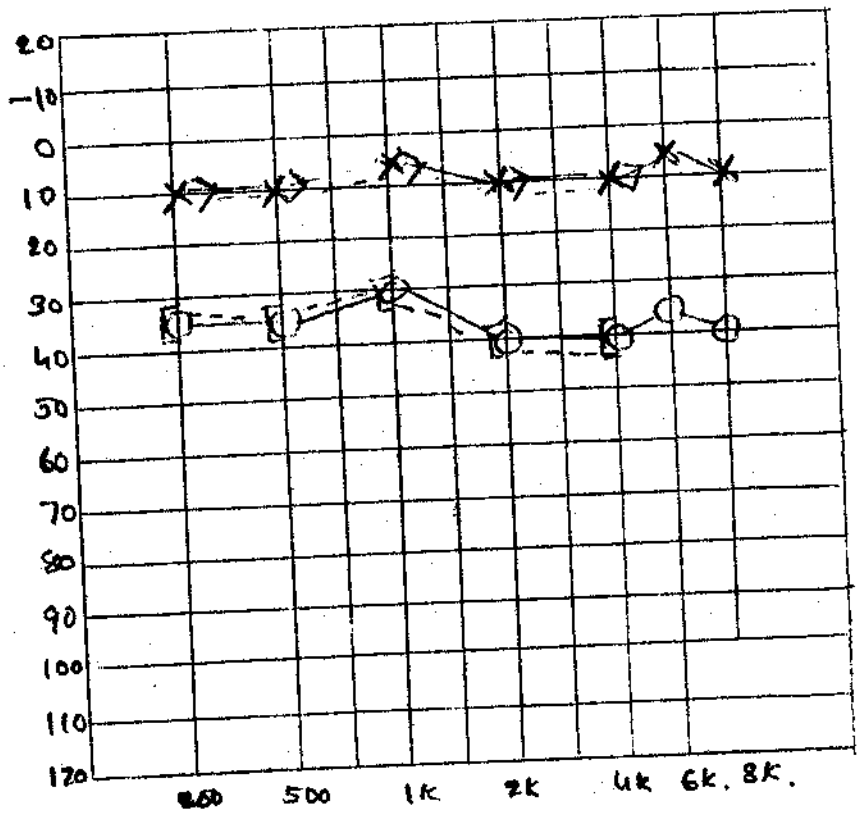
2. 90dBSPL

1. Do you mask the laft ear while administering modified SISI tesT?

2. Calculate minimum and maximum masking for administering modified SISI test, at 2KHz, and 4KHz.

3. Caluculate maximum mnsking for conventional SISI test and modified SISI test an 1KHz.

4. How is that maximum masking for conventional SISI and modified SISI are same?



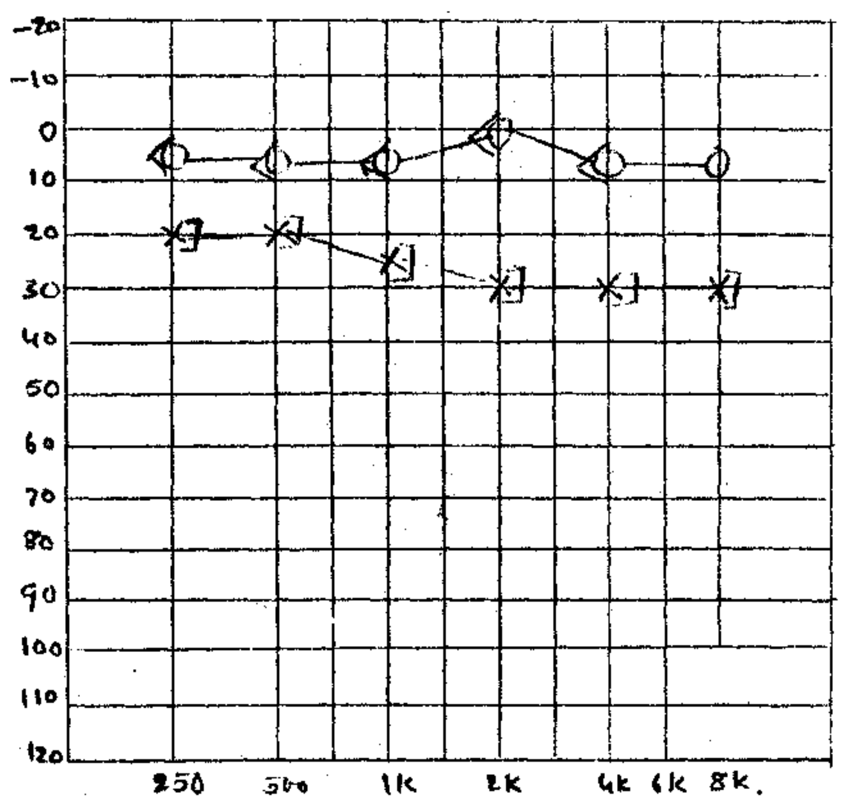
Answer: 1. Yes. SISI' modified test is administered at 75dPBHL hence there is chance for cross hearing.

2.M Min.=86dB. M max=85dB.

3. Max. noise for coventional SISI is 85dB
Max. noise for modified SISI is a so 85dB.

4 Because noise is presonted through same ear phone

1. Is there a need to mask during tone decay test (Olson test) at 2K and 4K?



Answer:1. Yes. Because tone decay (1sen) test is administered at 20 dBS1.Thus when we give 50dB bove tone to left ear, there is chance for cross hearing.

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