MASKING FACTOR
IN NORMAL AND PATHOLOGIC EARS

Reg. No. 8406
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An Independent Project work submitted as part fulfilment
for First Year M.Sc. (Speech and Hearing) to the
University of Mysore.

ALL INDIA INSTITUTE OF SPEECH AND HEARING
MYSORE - 570 006.

To
My Father,

who is a constant source of moral support

and

My Mother,

who inspires me towards higher academic achievement.

CERTIFICATE

This is to certify that the independent project entitled.

'MASKING FACTOR IN NORMAL AND PATHOLOGIC EARS', is the bonafide work, done in part fulfilment for First Year M.Sc. (Speech & Hearing), of the student with Registration Number: 8406

Director

All India Institute of Speech and Hearing,
Mysore - 570 006.

CERTIFICATE

This is to certify that the Independent Project entitled:

'MASKING FACTOR IN NORMAL AND PATHOLOGIC EARS'

has been prepared under my supervision and guidance.

(Guide)

Declaration

This Independent Project entitled

'MASKING FACTOR IN NORMAL AND PATHOLOGIC EARS'

is the result of my own work undertaken under the guidance of Dr. M.N. Vyasamurthy, Lecturer in Audiology, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier at any University for any other Diploma or Degree.

Mysore Register No. 8406
Date:

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CHAPTER I

INTRODUCTION

Everyday listening goes on in a fairly complex acoustic environment. We usually listen to speech or music against a background of noise or of other voices. Remarkably enough, we see/m be able to single out the signal, which we wish to hear, and to suppress the effects of the noise or unwanted extraneous sound. We cannot, however, always hear the voice of our neighbour in the noisy market; at some point the noise becomes too great and masks the voice. Masking, is then, a kind of exception to our ability to analyze out of a complex of sounds, the one to which we wish to attend. It is one way in which a sound affects the audibility of another sound.

It is this basic principle which has been greatly put to use, by the audiologist, in routine audiometric testing, under the title of "Clinical Masking".

Masking has been defined in various ways by a number of authors. However, for clinical purposes it may be defined as "the amount by which the threshold of audibility of a sound is raised by the presence of another (masking) sound". (ANSI S 1.1, 1960).

Masking is fundamentally an ipsilateral phenomenan. (Menzel, 1968). What this means is that the masker can exert masking effect on the maskee only if both masker and maskee are presented to the same ear simultaneously with the exception of central masking.

The ipsilaterality of masking is basic to its application in audiometry, since otherwise we could not confine the masking to only one ear any more than the test tone (Menzel, 1968). In the clinical setting, the tone and the noise are presented to opposite ears. Whenever cross-hearing is suspected, it is necessary to remove the non-test ear from the test procedure to determine: (1) if the original responses were obtained through the non-test ear, and (2) when the original responses were obtained through the non-test ear, what the true threshold of the test ear really is. The only procedure by which this can be accomplished is to deliver a noise to the non-test ear, in order to remove it from the test procedure, by masking.

Under this condition, two types of masking are in evidence. The first occurs when the masking stimulus is presented to one ear at a level insufficient to effect the threshold of the opposite ear directly. Nevertheless, the threshold will be elevated about 5 dB. The term "central masking" as introducedby Wegel and Lane (1924) is used to denote this factor on the assumption that this shift in threshold of the opposite ear is a central Nervous System Function.

The second type of masking is the threshold shift which occurs when the noise directly effects the threshold of the ear whose threshold is being measured. At any given time this may be the tested ear or the masked ear. If a threshold shift occurs when the tone and noise are presented to opposite ears, either the threshold of the tone is determined by the masked ear (too little or no masking) resulting in undermasking, or the noise is strong enough to elevate the threshold of the test ear (too much masking) resulting in overmasking.

For some clinicians the approach to masking is a haphazard, hit-or-miss, bit of guesswork with no basis in any set of principles. (Sanders, 1978). They simply present some arbitrarily chosen level of noise and hope for the best. This behaviour is reinforced by the fact that it seems to work in many cases. Moreover, "various writers have presented procedures designed to simplify the clinicians task. Unfortunately, the simplest procedures provide the greatest opportunity for error" (Studebaker, 1967).

Thus the mere fact of having used masking is not enough to insure correct measurement, that improper use of masking can itself introduce error. More errors are committed in audiometry through careless or improper use of masking than through its omission. Most of these errors result from either too much or too little masking (Menzel, 1968).

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 practise. (Studebaker, 1967).

It is seldom clear just what intensity values are indicated by the graduations on the masking control - sound pressure levels, hearing levels or effective masking levels. While methods for determining the proper levels of masking have been worked out, they cannot be explained unless the examiner performs considerable experimentation with a given audiometer to develop information as to the effectiveness of various dial setting in masking tones in normal ears (Newby, 1964). Therefore, before examining persons with hearing loss, the clinician must know the minimum masking level for subjects with normal hearing. He should, therefore, determine the masking factor for each frequency, as an initial step in the masking procedure. This raises the question - What is masking factor? Masking factor is the difference between the noise level and the tone level (Vyasamurthy, 1972). For example, a 40 dBSPL noise may not be sufficient to mask a 40 dBHL tone, when tone and noise are presented to the same ear. The noise level would perhaps, have to be increased to 20 dB, to just mask the tone. Here, the masking factor is then 20 dB. It is also known as the effective masking level. This is a property of the masking noise and varies with the frequency and the type of noise used (Staab, 1975).

Masking Factor is one of the most important variables in clinical masking. If the masking noise used in masking the test tone is not effective, whatever care is taken to calculate the optimum masking level (to rule out the participation of the non-test ear) would be futile. Thus, it is essential that the audiologist is sure of the masking factor of the masking noise used in obtaining the masked thresholds, and should take the values of masking factor into consideration, while determining the minimum and maximum masking levels.

The intensity calibration of masking noises in terms of effective masking possesses certain serious limitations.

The amount of masking noise indicated on the noise gain control dial assumes that the noise is applied to a normal ear. The dial reading therefore is incorrect when noise is applied to a "better ear" with a significant hearing impairment (Glorig, 1965).

The present study attempts to find whether the masking factor obtained using normal subjects could be used in the masking procedures for pathologic ears.

The following null hypotheses were put forth.

I. There is no significant difference in the masking factor obtained at different levels (0 dBSL, 10 dBSL, 20 dBSL, 30 dBSL and 40 dBSL) in normal ears.

II. There is no significant difference in the Masking Factor obtained at different levels (0 dBSL, l0 dBSL, 20dBSL, 30 dBSL, and 40dBSL) in ears with conductive pathology.

III. There is no significant difference in the Masking Factor obtained at different levels (OdBSL, lOdBSL, 20dBSL, 30dBSL and 40dBSL) in ears with sensori neural pathology.

IV. There is no significant in the Masking Factor across various frequencies (350 Hz, 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz) in normal ears.

V. There is no significant difference in the Masking Factor across various frequencies (250 Hz, 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz) in ears with conductive pathology.

VI. There is no significant difference in the Masking Factor across various frequencies (250 Hz, 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz) in ears with sensori neural pathology.

VII. There is no significant difference in the Masking Factor between normal ears and ears with conductive pathology.

VIII. There is no significant difference in the Masking Factor between normal ears and ears with sensori neural pathology.

IX. There is no significant difference in the Masking Factor between ears with conductive pathology and ears with sensori neural pathology.

CHAPTER 2

REVIEW OF LITERATURE

"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, 1964).

Over the past 40 or more years masking generally has been operationally defined, often as follows: "Masking is the elevation in the threshold for one signal (the test tone) by the presence of a second signal (the masking noise)" (Sanders, 1978). Not everyone has been willing to accept this definition.

Meyer (1959), for example, insisted that the definition should be expanded to include the reduction in loudness in a stimulus that occurs under certain circumstances upon the introduction of other signals. Scarf (1964) used the term "partial masking" to refer to this loudness reduction phenomenon.

Masking refers to the limits placed on the recognition of a sound by the presence of another sound, when the time and frequency characteristics of both are known to the observer, and when he is oriented to percieve them.

The definition includes intra aural distortion products as one of the consequences of both stimuli". (Carter and Kryter, 1962).

Deatherage and Evans (1969) stated that masking is "the process by which the detectability of one sound, the signal, is impaired by the presence of another sound, the masker". The definition was devised to be consistent with signal detection theory concepts in that it does not include the word 'threshold'. However, in other regards, it is fundamentally unchanged from the earlier definitions.

For clinical purposes masking is best described procedurally as follows: the threshold of a signal is first found in quiet and then in the presence of a second stimulus. The difference in dB between the two thresholds of the first stimulus measured under the two different conditions is a measure of the masking produced by the second (Licklider, 1951). The description implies that the test stimulus and the masking stimulus are presented to the same ear. The number of decibels of threshold shift in the first stimulus by the second stimulus at a given intensity designates the effective level of the second stimulus. The smaller the intensity required to produce a given threshold shift, the greater the efficiency of the particular masking stimulus (Zwislocki, 1951).

The relative effectiveness of a masking noise on a pure tone is determined by several variables including the spectrum of noise, how the masking level dial is calibrated (i.e. its dB reference and the linearity of the dial) and the kind of earphone used to deliver the noise to the masked ear. When these variables are understood and controlled, the task of masking becomes considerably easier (Martin, 1975).

There are several different kinds of masking noises available on commercial pure tone audiometers. They may be classified as:

1. Pure tones
2. Warble tones
3. Compressed air
4. Noise
    (a) Complex noise
        (i) Square wave noise
        (ii) Saw tooth noise
    (b) Broad Band Noise
    (c) Narrow Band Noise.
    (d) Speech Noise
    (e) Pink Noise.

Each noise has a characteristic spectrum and therefore provides a different degree of masking efficiency at different frequencies. Martin (1975). It is generally agreed (Denes and Naunton, 1952; Rood, 1960; Liden, Nilsson and Anderson, 1959; Sanders and Rintelmann, 1964; Studebaker, 1962, 1964; Zwislocki, 1951) that narrow band noises which centre at the test signal frequency are the most efficient maskers of pure tones, i.e. they produce a given effective level with the least intensity and therefore, the least loudness (Table 2.1).

Since it has been proved that masking of a tone is most efficiently accomplished by frequencies immediately surrounding that tone (Fletcher, 1940; Fletcher and Munson, 1937), the additional frequencies used in the broad band noise are redundant. (Fig. 2.1, Fig. 2.2). They supply additional sound pressure and loudness to the patient with no increase in masking efficiency. Fig. 2.3 shows the elevation in threshold of a pure tone of 1,000 cycles in the presence of white noise. The noise intensity is expressed in dB above normal threshold and it will be seen that below the 20 dB level it produces negligible masking of the pure tone. Above this level, there is an incremental equivalence in dB of masking and of masking noise intensity. At any masking level, therefore, the loudness of the white noise, will be much in excess of the pure tone, since its intensity will at all times be some

20 dB higher. In contrast to the masking effect of white noise, there is 100% masking efficiency with narrow band noise. The curve begins at zero and there is exact one to one relationship between noise level and masked threshold (Hood, 1960).

Surrounding every pure tone there is a critical band of frequencies that provides maximum masking with minimum sound pressure. (Fletcher, 1940; Fletcher and Munson, 1937). Narrowing the band to less than the critical band width requires greater intensity for masking a given level of tone, and conversely, adding frequencies outside the critical band increases intensity without increasing masking (Fletcher, 1940).

Narrow band noise, therefore has the greatest, masking efficiency if the important factor in terms of intensity is the level per cycle in the critical band rather than the overall intensity.

Level per cycle - overall intensity minus 10 times the logorithm of the band width, i.e. LPC = OA SPL - 10 Log BW. The LPC for narrow band noise would be greater, than for white noise. In other words the threshold shift is greater (Sanders, 1978).

Table 2.1: Showing dBSPL of noise necessary to mask odB HTL tones (These values are based on. unpublished data collected at the Florida State Univ. as well as published by Liden (1954) and Sanders and Rintelman (1964)).

Noise Type	Frequency in Hertz					
	250	500	1000	2000	4000	8000
Saw Tooth	49	44	45	56	61	85
White	48	33	28	30	22	22
Narrow Band	32	17	14	18	14	26

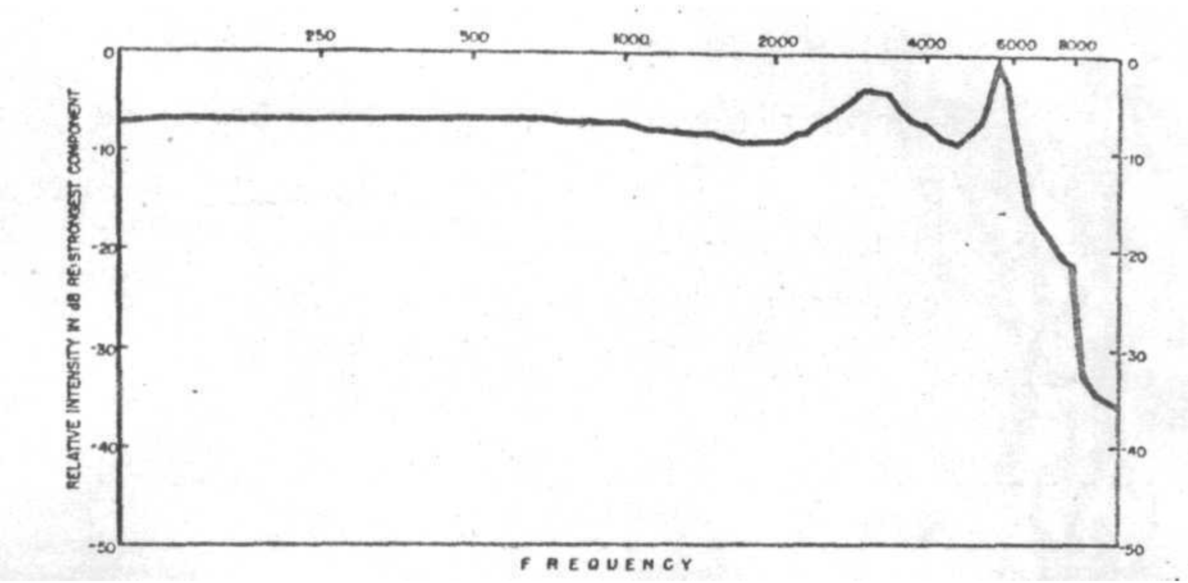
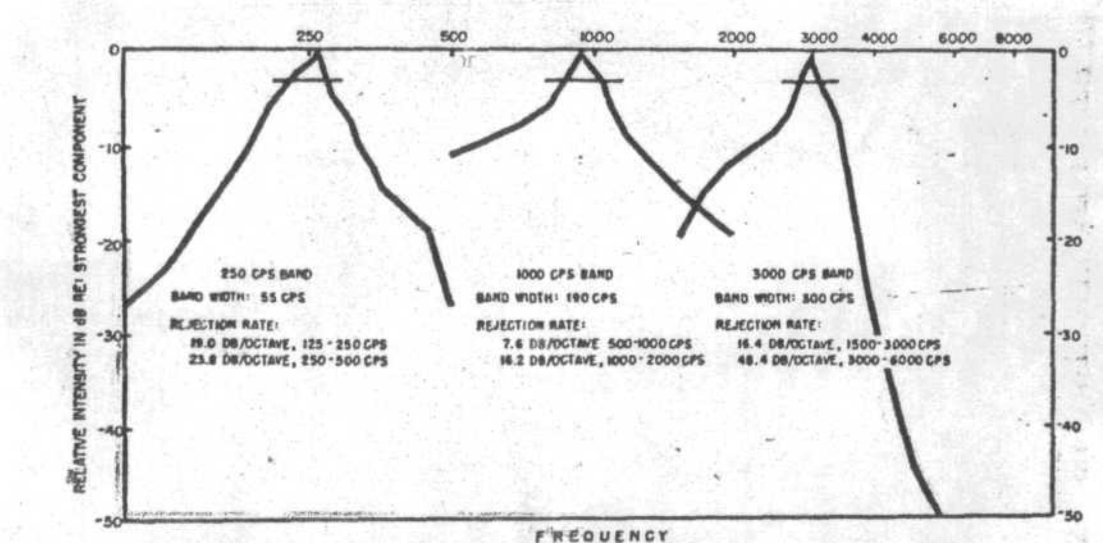


Fig .2.1: Acoustic spectrum of a broad band white noise through a THD-39 earphone From J. W. Sanders and W. F. Rintetmann, Archives of Otolaryngology. 80, 541-558,1964.



Acoustic spectra of three narrow bands of noise through a hearing aid receiver. From J. W. Sanders and W. F. Rintetmann, Archives of Otolaryngology, 80 556.1964.

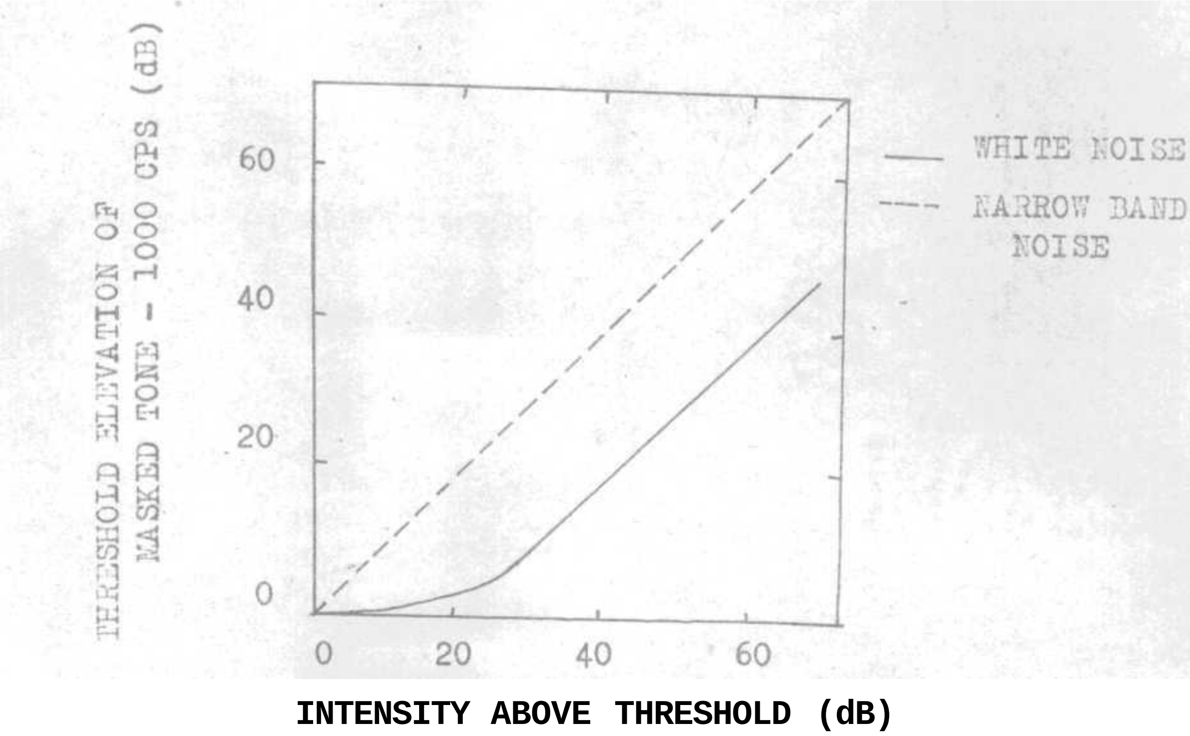


FIG. 2.3: Showing the elevation in threshold of a pure tone of 1000 cycles in the presence of white noise.

The use of narrow band noise offers the further convenience 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).

Most modern audiometers have a provision for narrow band noise presentation. Even with "broad spectrum" noises there are differences as great as 30 to 40 dB between the threshold shift that the noise at a given level produces for some frequencies as compared to others. This is to be expected because the sensitivity of the normal ear is not the same for various frequencies, and the relatively greater intensity of a tone near the frequency limits of human hearing needed for audibility requires correspondingly higher intensity noise to mask it (Menzel, 1968).

It follows that whatever numbers appear on the masking level control of the audiometer must be regarded as meaningless unless the instrument has been separately calibrated for masking effectiveness at each test frequency and appropriate correction tables used (Menzel, 1972). Some clinical audiometers producing white noise as a masker provide a set of numbers on the dial labelled "Effective Masking". The numbers may be approximately correct for one or two frequencies, probably in the area of 1000 Hz but cannot be applied to all test frequencies (Sanders, 1978).

Effective masking has been defined as the noise level needed to mask a threshold tone or produce a threshold shift (Staab, 1975). It is also called Masking factor and is defined as the noise level minus the tone level (Vyasamurthy, 1972). Rose (1978) calls it as minimum masking level and defines it as the amount of noise needed to mask a 0 dBH TL tone.

At high intensity levels (above 20 dB), a given dB increase in the level of masking results in approximately equal increases in the amount of masking or threshold shift of the test tone, thus producing a linear relationship, as shown in the table 2.2 (Glorig, 1966).

Thus if the effective level is determined according to the normal ear and expressed in dB on the hearing threshold level scale, it can be interpreted as the hearing threshold level to which an ear will be shifted by a given amount of noise. If these effective levels are related to the numbers on the audiometer masking dial for each frequency, the masked threshold that will be produced by each setting of the dial can be predicted. (Sanders, 1978).

Masking factor in a 2 channel audiometer is calculated using a group of 6 to 10 normal hearing subjects or subjects with known sensori neural hearing loss. The threshold for the tone is found in the presence of varying amount of noise (Fig. 2.4), tone and noise being presented through the same earphone (Fig. 2.5) (Studebaker, 1964).

While Studebaker's methodology is workable, it involves a number of steps which may be unnecessary and are atleast cumbersome (Martin, 1967). Martin (1967) recommended finding the noise required to mask a 30 dBHL tone in reliable normal hearing subjects. However, no signicant difference was observed for the masking factor values using the two methods (Joan D'Mello, 1981).

Masking factor is determined by calculating the noise required to produce a shift in threshold of the patient's own non test ear (Veniar, 1935).

With audiometers that donot permit mixing of tone and noise through the same earphone, masking factor is calculated using a group of listeners with severe or total unilateral sensori neural hearing impairment. The level of cross over is determined and then increased by 30 dB in the impaired ear with masking noise introduced

Table 2.2: Showing the linear relationship between masking noise and tone, at high intensities (Glorig, 1966)

To Mask	Noise Level Required
0 dB tone	20 dB
20 dBtone	20 + 20 = 40 dB
30 dB tone	30 + 20 = 50 dB
40 dB tone	40 + 20 = 60 dB
50 dB tone	50 + 20 = 70 dB
60 dB tone	60 + 20 = 80 dB
70 dB tone	70 + 20 = 90 dB

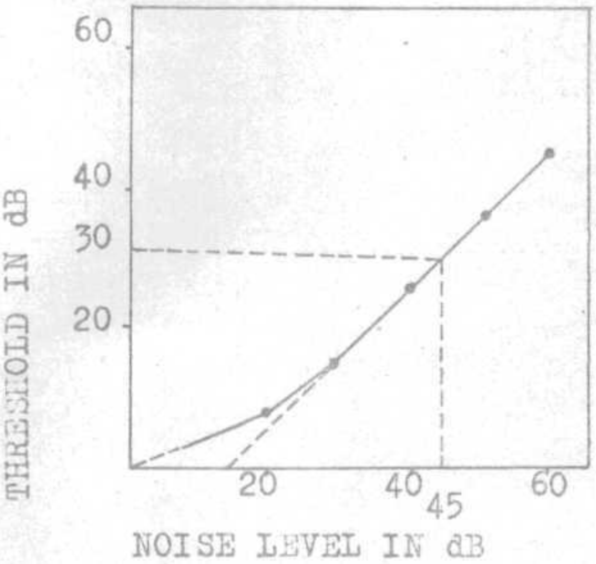


FIG. 2.4: Showing the relationship between masker level and test signal threshold when the test signal frequency is within the noise band. Minimum masking is 15 dB in this example. (Studebaker, 1964).

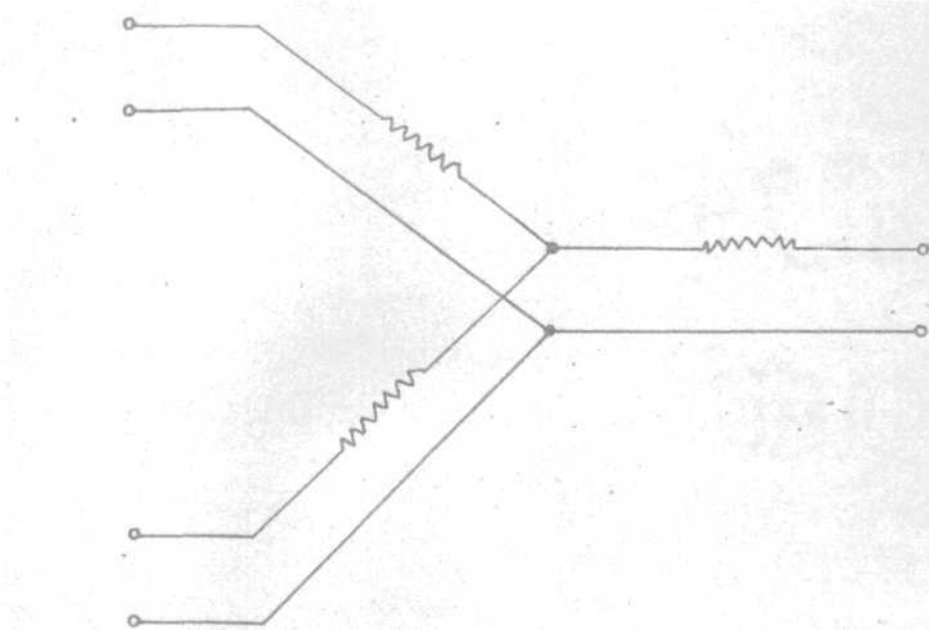


FIG. 2.5: A combing network to deliver both noise and the tone to the same ear as suggested by Studebaker (1967).

to the normal ear. The level of noise required to mask the tone in the normal ear is determined (Studebaker, 1964).

Masking factor may be calculated mathematically using the critical band concepts of Fletcher, 1940. "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" (Fletcher, 1940; Fletcher and Munson, 1937). Therefore, an estimate of the acoustic energy in the critical band, can predict the masking effect. At a given frequency, the effective level Z = Level per cycle + 10 log Critical Band Width - threshold in quiet (db SPL).

The establishment of minimum masking level norms for each masker - an increasingly common clinical practise - is criticised by Veniar (1965). She points out that individual subjects deviate considerably from normative standards. Moreover, noise constituting effective masking in a normal ear cannot be extrapolated to a ear with losses (Veniar, 1965; Glorig, 1965). The very pattern of loss changes the quality and effectiveness of white noise (Denes and Naunton, 1952; Zwislocki, 1951). She therefore suggest that a more valid procedure is to establish minimum masking levels for each subject, at each frequency.

It is advisable to add approximately 10 dB of noise after calibration to account for the inter subject variability with respect to the "effectiveness" of effective masking levels. (Martin, 1974).

The indicated amount of effective masking is misleading while making bone conduction measurements. This is due to the fact that the effective masking concept compensates for the air conduction shadow curve (50 dB approx.), whereas the bone conduction shadow curve is so small it is insignificant. Also placement of a masking noise earphone over a normal middle ear increases the bone conduction sensitivity in such a ear by several dB, especially at frequency levels below 2000 c/s. Unfortunately the effective masking level indicated on the dial can be relied on only while making air conduction measurements on unilateral impairments (Glorig, 1965).

Langenbeck (1953) reported that in cases with conductive deafness, the monaural masked threshold was similar to that of the masking level of the noise. In the instance of sensori-neural hearing losses of more than 40 dB, the tone being masked had to be more intense than the masking noise before it could be detected. He therefore, used this in the differential diagnosis of hearing impairment.

Palva, Goodman and Hirsh put Langenbeck's findings to test and found that the threshold did not produce the same results that he had indicated. With a noise level of 100 dB they found that thresholds for all of the frequencies tested were nearly the same for all types of hearing losses, and concluded that it is not a useful indicator for differential diagnosis of hearing impairment.

Studebaker (1964) and Martin (1967) include the addition of the minimum masking levels for normals (Masking Factor) in the formula for the minimum and maximum level of masking noise required to rule out the participation of the non test ear, in both air conduction and bone conduction testing procedures.

As the masking factor is being used in the clinical masking procedure during routine testing, and due to the difference of opinion existing, as can be seen in the literature, much investigation is required for a better understanding and evaluation. The available literature doesnot report of any study of masking factor conducted on a clinical population. The present study was undertaken to investigate the masking factor in pathologic ears as compared to normal ears.

CHAPTER 5

METHODOLOGY

The study was aimed at investigating the masking factor in normal and pathologic ears, across different frequencies and hearing levels. The study consisted of the following steps:

1. Selection of subjects
2. Finding out the pulsed pure tone thresholds of frequencies 250 Hz to 4000 Hz in normal hearing subjects.
3. Finding out the level of narrow band noise just sufficient to mask the pulsed pure tones presented at threshold level, 10 dBSL, 20 RBSL, 30 dBSL, and 40 dBSL, at each of the above frequencies, in normal hearing subjects (ipsilateral masking).
4. Obtaining similar data in subjects with mild or moderate conductive and sensori neural hearing loss.

Subjects:

Twenty ears with normal hearing (according to Goodman's (1965) classification of hearing impairment; ref: ANSI, 1969) were chosen for the study. All these subjects were adults and were free from any otologic complaint, prior to and at the time of testing.

The clinical population comprised of two groups of adult subjects. The first group included fourteen ears with mild or moderate sensori neural hearing loss, while the second group comprised of eighteen ears of mild or moderate conductive hearing loss.

Instrumentation:

A dual channel clinical audiometer, Beltone 200 C, with TDH-49 earphones, enclosed in Mx41/AR ear cushions was used for testing.

Fig. 3.1 best illustrates the operational availabilities in Beltone 200 C.

This audiometer provides for testing frequencies from 125 Hz to 8000 Hz. The hearing level ranges from 0 dB to 110 dB. Pulsed pure tones may be presented by selecting the automatic position. The tone is presented at the rate of 0.3 sec "on" and 0.3 sec "off".

Narrow band noise is available in channel two of the audiometer, with a HL range from -10 dB HL to 100 dB HL. The relationship between the hearing level dial reading and the SPL output is presented in Table 3.1. Simultaneous presentation of noise with pulsed pure tones, through the same earphone is possible, by setting

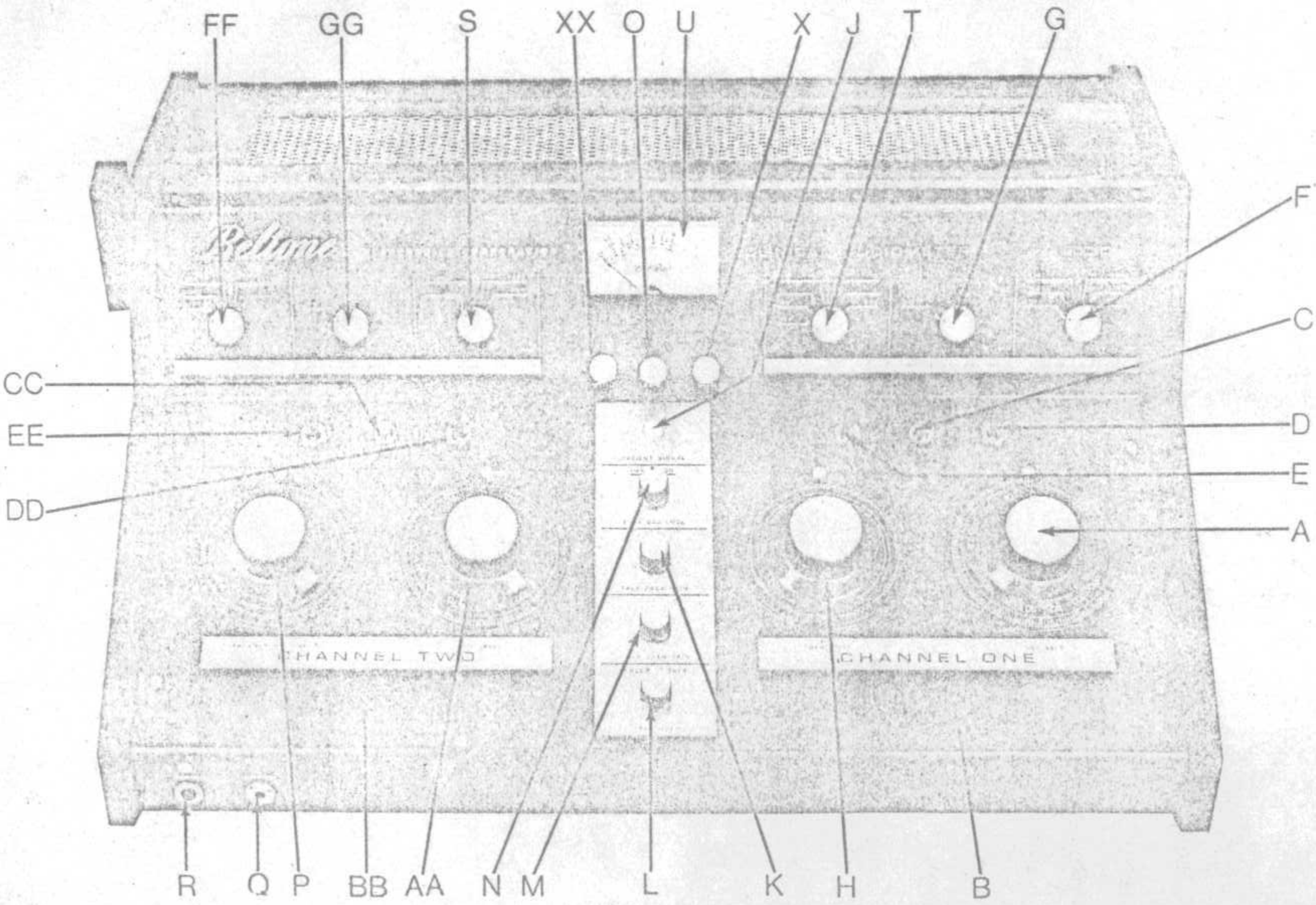


FIGURE 3.1 ILLUSTRATION, OPERATING CONTROLS OF BELTONE 200 C

Front Panel Indicators - Control Knobs of Beltone 200 C

A	(AA)	Output (Hearing Level Control)
B	(BB)	Tone Interruptor
C	(CC)	Tone 'on' lamp.
D	(BE)	Automatic/Manual Switch
E	(EE)	Tone Reversing Switch
F	(FF)	Output Selector
G	(GG)	Monitor Control
H		Frequency
J		Patient Signal Lamp
K		Talk Back Gain
L		Talk Over Switch
M		Talk Over Gain
N		Tone Bar Lock
0		VU Meter Selector Switch
P		Frequency Input
Q		Monitor ear phone
R		Power
S		Speech Unit
T		SISI
U		VU Meter
X		Channel one VU Meter Gain Control
XX		Channel Two VU Meter Gain Control

Table 3.1: Showing the relationship between the hearing level dial reading and the SPL output.

Centre Frequency in Hertz	Dial Reading in dBHL	Output in dBSPL	Difference
250	80	100	20
500	80	88	8
1000	80	85	5
2000	80	86	6
4000	80	87	7

the output selector of both the channels to the same ear. Noise may be presented continuously by manipulating the tone reversing switch of channel two.

Calibration Procedure Used:

The dual channel clinical audiometer (Beltone 200 C) was claimed, by the manufacturer, to be calibrated to the ANSI (1969) standards. However, to ensure accuracy in calibration, the audiometer was calibrated periodically during the study according to the guidelines given by Wilber (1978).

Fig. 3.2 illustrates the set up for calibration.

The audiometer Beltone 200 C was turned 'on' and was allowed to warm up. The sound Level Meter (B and K 2203) was set as follows. The meter switch was turned to 'external filter' and to 'slow'. The weighting switch was in the 'off' position. The signal ear phone (TDH 49 with M x 41/AR ear cushions) of the audiometer was removed from the head band and was placed over the coupler of the artificial ear (B and K 4152). The ear phone was held in place by means of a tension of the artificial ear and was adjusted to 0.5 kg of pressure. After initial placement of the earphone on the coupler, a low frequency tone (250 Hz) was introduced and the

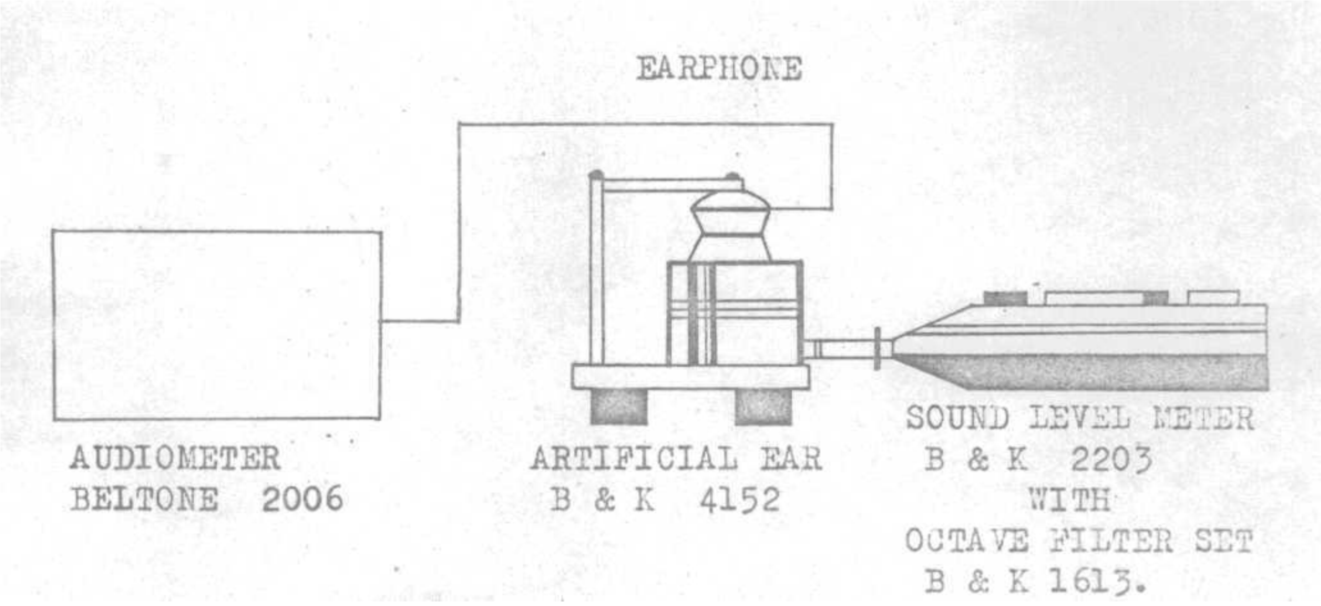


FIG. 3.2: Block Diagram of Pure Tone and Narrow Band Noise calibration.

earphone was readjusted until the sound level meter needle read the highest intensity. This is said to ensure best placement according to Wilber (1978). The frequency selector of the audiometer was set to 1000 Hz. The Octave Filter (B and K 1630) of the sound level meter was set to 1000 Hz. The audiometer was set to right ear phone (selector switch) and the tone was continuously 'on'. The hearing loss dial was set to 60 dB for the frequency chosen. The reading on the sound level meter was noted. Similarly other frequencies (250 Hz, 500 Hz, 2000 Hz and 4000 Hz) were checked. The audiometer output intensity was within permissible limits.

To check the linearity of the attenuator of the audiometer, a similar set up was used. The range finder was set to 120 dB. The hearing loss dial was set at maximum and output of the sound level meter was noted. The hearing level dial was dropped in 5 dB steps and the reading on the sound level meter was noted for each 5 dB drop. The reading on the Sound Level Meter showed that the audiometer linearity was satisfactory.

The earphone output level for narrow band noise was checked in the same way as for pure tones, the only difference being, instead of pure tones, narrow band noise was introduced. The hearing level dial was adjusted to

80 dBHL to avoid interference with extraneous noise. The sound level meter was set to 'Linear' setting. The readings on the sound level meter were within expected levels.

Environment:

The audiometric tests were performed in a sound treated room at the Institute of Speech and Hearing, Bangalore. A sound treated two-room situation was used, so that the control panel of the audiometer was not visible to the subject. The ambient noise levels in these rooms were within the maximum permissible noise levels.

Procedure:

The study was conducted in two phases.

In the first phase of the study the pulsed pure tone thresholds were established for frequencies 250 Hz, 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz. The 'Up 5 Down 10' method with principles of the Hughson-Mastlake Ascending Technique (Green, 1978) was used. The controls on the audiometer were set as follows:

Channel One

Control	Position
Frequency	Desired frequency
Output Selector	Desired ear
Tone Reversing Switch	'On'
Automatic/Manual Switch	'On'
Interrupter	Released (when depressed tone is interrupted)

Channel Two

'Off'

In the second phase of the study, pulsed pure tones were presented continuously at five different levels at (Threshold level, 10 dBSL, 20 dBSL, 30 dBSL, 40 dBSL) at each of the frequencies from 250 Hz to 4000 Hz. Simultaneously narrow band noise with the corresponding centre frequency was presented through the same earphone and the level of noise just sufficient to mask the pulsed pure tones established. The controls on the audiometer were set to the following positions.

Channel One

Control	Position
Frequency	Desired frequency
Output (Hearing Level Control)	Desired Level
Output Selector	Desired ear.

Tone Reversing Switch	'On'
Automatic/Manual Switch	'On'
Interrupter	Released.

Channel Two

Control	Position
Frequency	Narrow Band noise
Output selector	Same as Chan. One.
Automatic/Manual Switch	'Off'
Tone Reversing Switch	'On'
Interrupter	Released.

Instructions to the subjects:

Prior to testing, the subjects were instructed as follows:

"Youx are going to hear a series of 'beeping' sounds, through this telephone-like instrument (earphones of the audiometer were shown to the subject). Whenever you hear the sound, whether soft or loud, raise your finger. Keep your finger raised as long as you hear the sound and put it down when you stop hearing. Remember to raise your finger every time you hear the sound. You may hear a buzzing sound sometimes, similar to the wind blowing. Ignore it and raise your finger only to the 'beeping' sound".

Provided with these instructions, the subjects were tested and with the responses thus obtained, the Masking Factor was calculated using the formula:

Masking Factor = Noise Level in dBHL - Tone Level in dBHL.

The data thus obtained were subjected to statistical analysis to verify the null hypotheses as reported in the Introduction.

CHAPTER 4

RESULTS AND DISCUSSION

The present study was undertaken to find the difference, if any, in the masking factor between normal and pathologic ears. The difference in masking factor between different intensity levels and frequencies was also studied. The frequencies considered were 250 Hz, 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz, at five intensity levels (0 dBSL, 10 dBSL, 20 dBSL, 30 dBSL and 40 dBSL). Narrow band noise with the corresponding centre frequency, was used for ipsilateral masking of the pulsed pure tones.

The mean and standard deviation of the masking factor at the five intensity levels studied (0 dBSL, 10 dBSL, 20 dBSL, 30 dBSL and 40 dBSL), at each of the frequencies, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz are presented in Table 4.1 for normal ears, Table 4.2 for ears with conductive pathology and Table 4.3 for ears with sensori neural pathology. To check for the significance of difference between the mean masking factor values at different levels, the t-test of significance was applied. The results are shown in Table 4.4, 4.5 and 4.6. The masking factor values were not significantly different in the normal ears at all the five intensity levels tested.

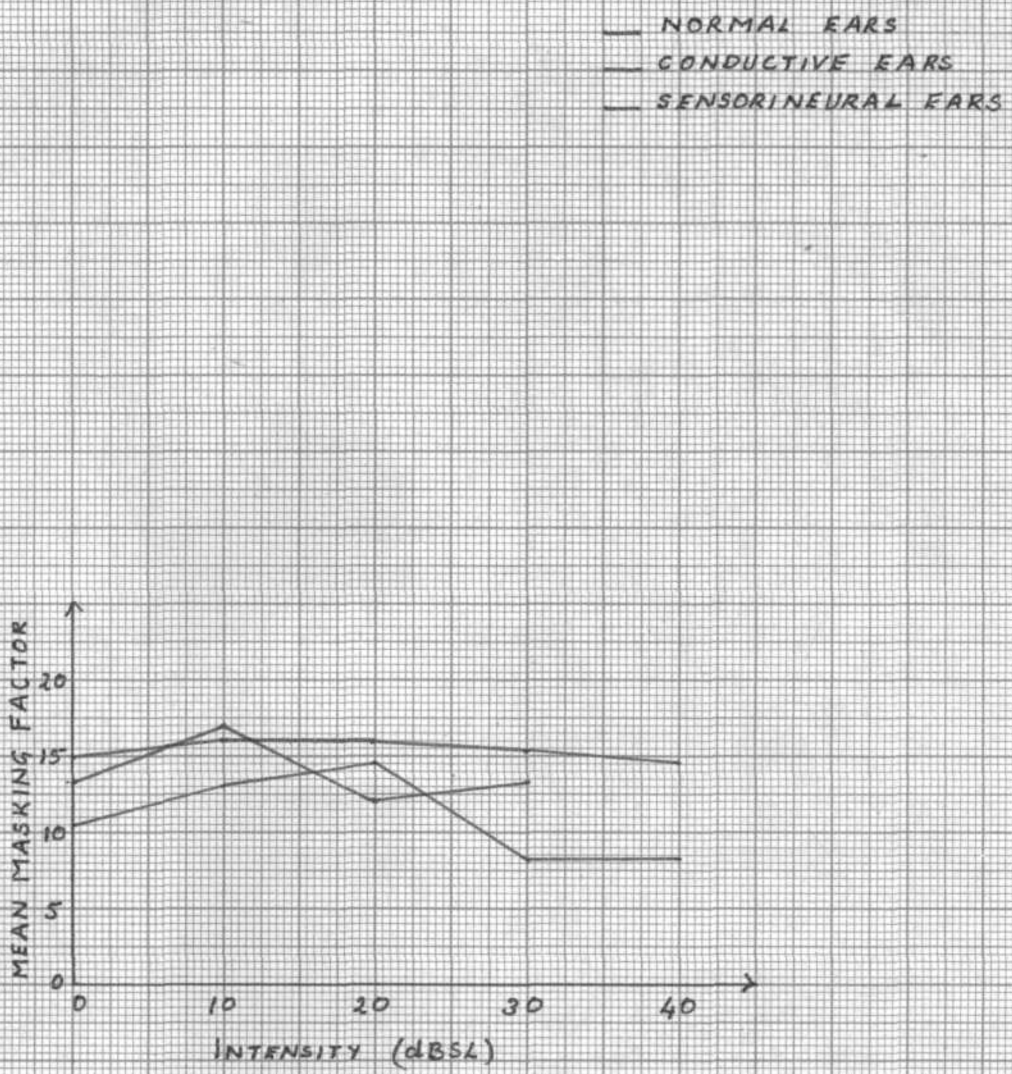
The similarity is also evident in the graphs 4.1 (a-e). Hence the null hypothesis I, stating that there is no significant difference in the masking factor obtained at different levels (0 dBSL, 10 dBSL, 20 dBSL, 30 dBSL and 40 dBSL) in normal ears was accepted.

In the pathologic ears, the results were similar, with a slight variation at 2000 Hz and 4000 Hz. In the ears with conductive loss, a significant difference (significant at 0.05 level) in masking factor was obtained between 10 dBSL and 40 dBSL and similarly between 20 dBSL and 40 dBSL and 2000 Hz. At all other levels for all frequencies, no significant difference in the mean values of masking factor was obtained.

In the ears with sensori neural pathology, a significant difference in the mean values were observed between 0 dBSL and 40 dBSL and between 10 dBSL and 40 dBSL at 2000 Hz, and similarly between 0 dBSL and 40 dBSL at 4000 Hz. These differences are obvious in the Graphs 4.1 (a-e). These results indicate that possibly, at high frequencies, a difference does exist in the masking factor, between low and high intensity levels, in pathologic ears. Hence, hypothesis II and III were partly accepted.

Table 4.1: Mean and standard deviation of the Masking Factor at various intensities in Normal ears.

Intensity	No.of Ears Mean S.D.	Frequency in Hertz				
		250	500	1000	2000	4000
0 dBSL	N	20	20	20	20	20
	$\bar{x}$	15.000	10.250	7.250	9.250	11.750
	σ	5.620	3.432	3.024	2.447	6.340
10 dBSL	N	20	20	20	20	20
	$\bar{x}$	16.000	11.000	7.500	9.250	13.750
	σ	5.026	3.839	3.035	2.447	6.043
20 dBSL	N	20	20	20	20	20
	$\bar{x}$	16,000	11.000	7.500	9.500	13.000
	σ	5.282	4.168	3.804	3.591	6.156
30 dBSL	N	20	20	20	20	20
	$\bar{x}$	15.250	11.500	7.750	9.750	12.250
	σ	6.172	4.894	3.432	3.796	6.973
40 dBSL	N	14	20	20	20	20
	$\bar{x}$	14.643	11.750	7.500	8.500	10.750
	σ	10.463	5.911	3.035	4.617	7.304

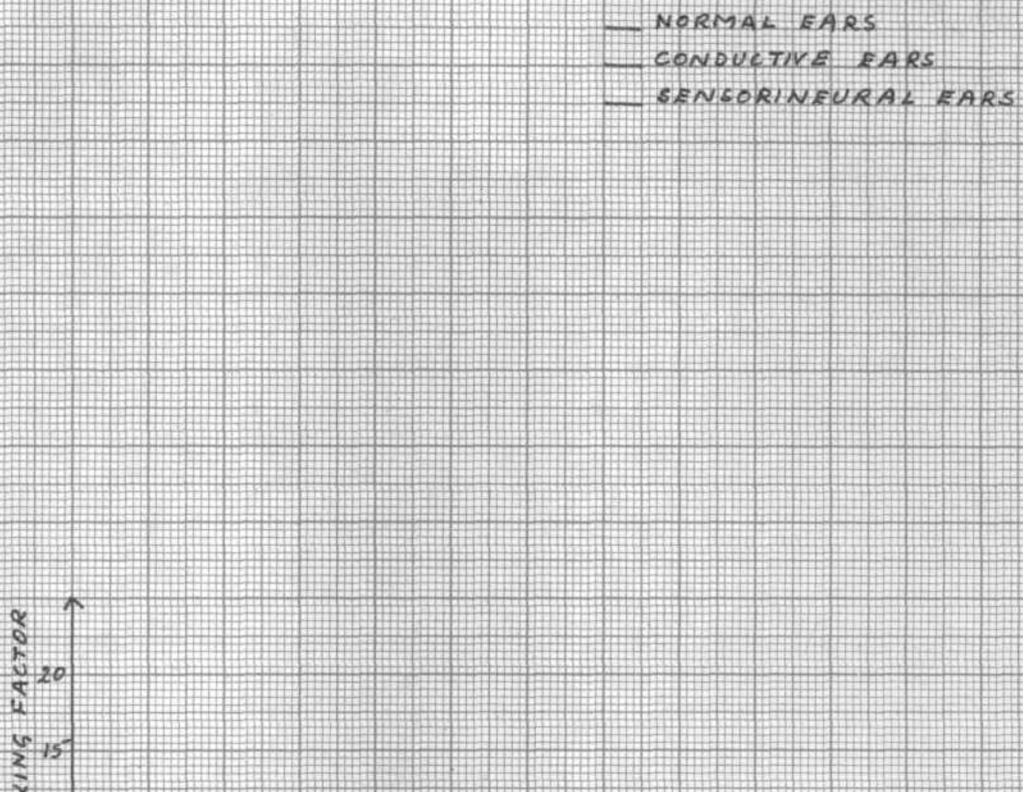


GRAPH 4·1(a): A COMPARISON OF THE MEAN VALUES OF MASKING FACTOR ACROSS VARIOUS INTENSITIES, AT 250 Hz.

Table 4.2: Mean and standard deviation of the Masking Factor at various intensities in ears with conductive hearing loss.

Intensity	No. of Ears Mean S.D.	Frequency in Hertz				
		250	500	1000	2000	4000
0 dBSL	N		18	18	18	18
	$\bar{x}$	13.333	3.078	4.722	5.278	10.278
	σ	3.086	7.778	3.196	2.081	5.809
10 dBSL	N		16	18	18	17
	$\bar{x}$	17,143	8.750	6.389	7.222	11.471
	σ	9.512	4.655	4.132	3.524	5.800
20 dBSL	N	5	12	16	17	17
	$\bar{x}$	12.000	7.083	4.688	7.353	9.118
	σ	4.472	3.343	3.400	3.999	6.900
30 dBSL	N	3	9	10	15	14
	$\bar{x}$	13.333	7.222	4.500	7.000	9.643
	σ	2.887	3.632	3.689	4.551	6.924
40 dBSL	N	CNE	6	9	9	8
	$\bar{x}$	CNE	7.500	5.556	3.889	8.125
	σ	CNE	2.739	5.270	3.333	8.839

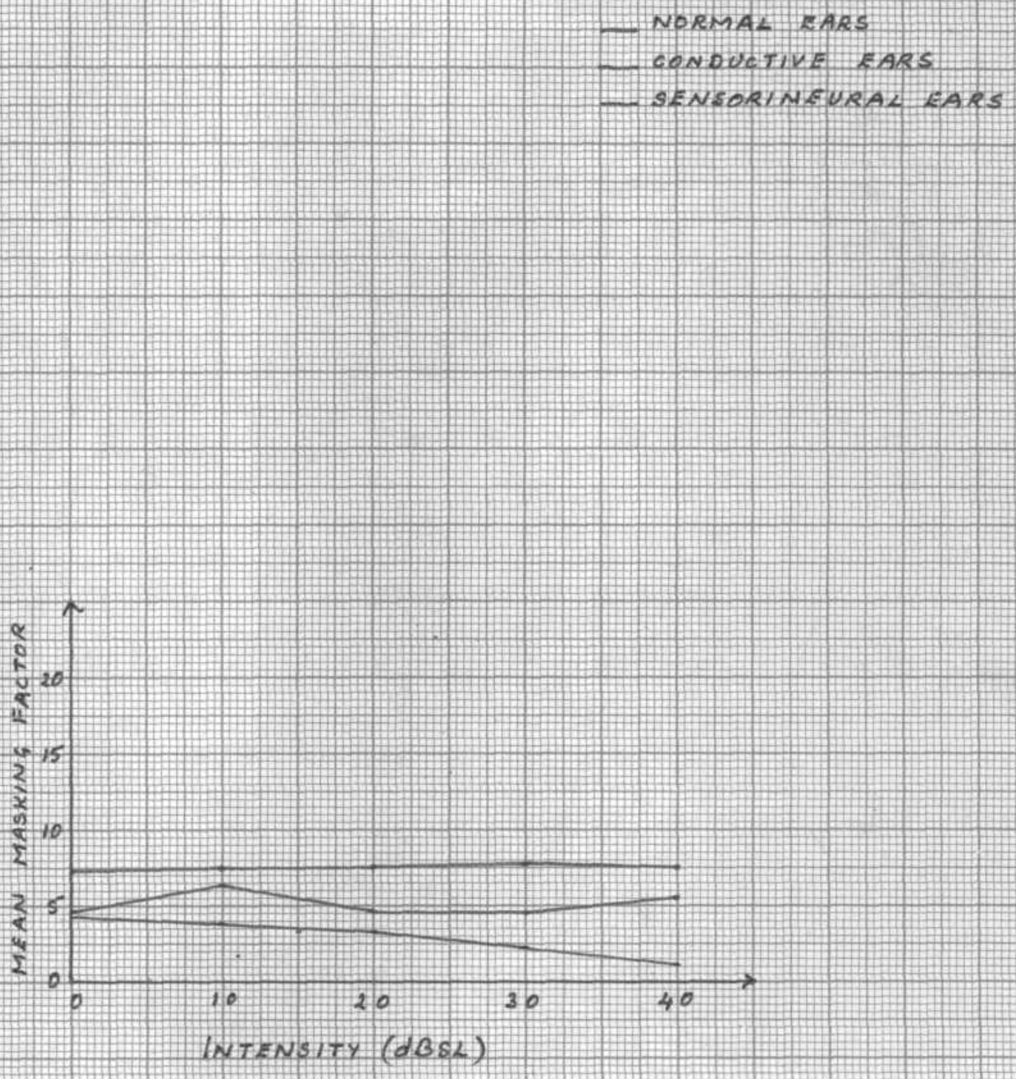
ONE = could not be established.



GRAPH 4.1 (b): A COMPARISON OF THE MEAN VALUES OF MASKING FACTOR ACROSS VARIOUS INTENSITIES, AT 500 Hz.

Table 4.3: Mean and Standard Deviation of the Masking Factor at various intensities in ears with sensori neural hearing loss.

Intensity	No.of Ears Mean S.D.	Frequency in Hertz				
		250	500	1000	2000	4000
0 dBSL	N	14	14	14	14	
	$\bar{x}$	10.357	6.429	4.286	4.643	7.857
	σ	4.584	2.344	3.315	3.079	4.258
10 dBSL	N	13	14	14	14	
	$\bar{x}$	13.077	7.500	3.929	4.286	6.429
	σ	4.804	3.798	3.496	3.315	5.345
20 dBSL	N	9	13	13	14	12
	$\bar{x}$	13.889	8.077	3.462	3.214	5.000
	σ	5.465	5.220	4.274	3.725	4.264
30 dBSL	N	3	12	13	11	9
	$\bar{x}$	8.333	7.917	2.308	1.818	4.444
	σ	2.887	5.823	5.250	5.135	5.270
40 dBSL	N	3	8	8	9	5
	$\bar{x}$	8.333	7.500	1.190	0	2.000
	σ	2.887	5.345	6.875	5.000	5.701



GRAPH 4·1(c): A COMPARISON OF THE MEAN VALUES OF MASKING FACTOR ACROSS VARIOUS INTENSITIES, AT 1000 Hz.

Table 4.4: Showing the significance of difference between mean values of Masking Factor across various intensities in ears with sensori neural hearing loss at 2000 Hz.

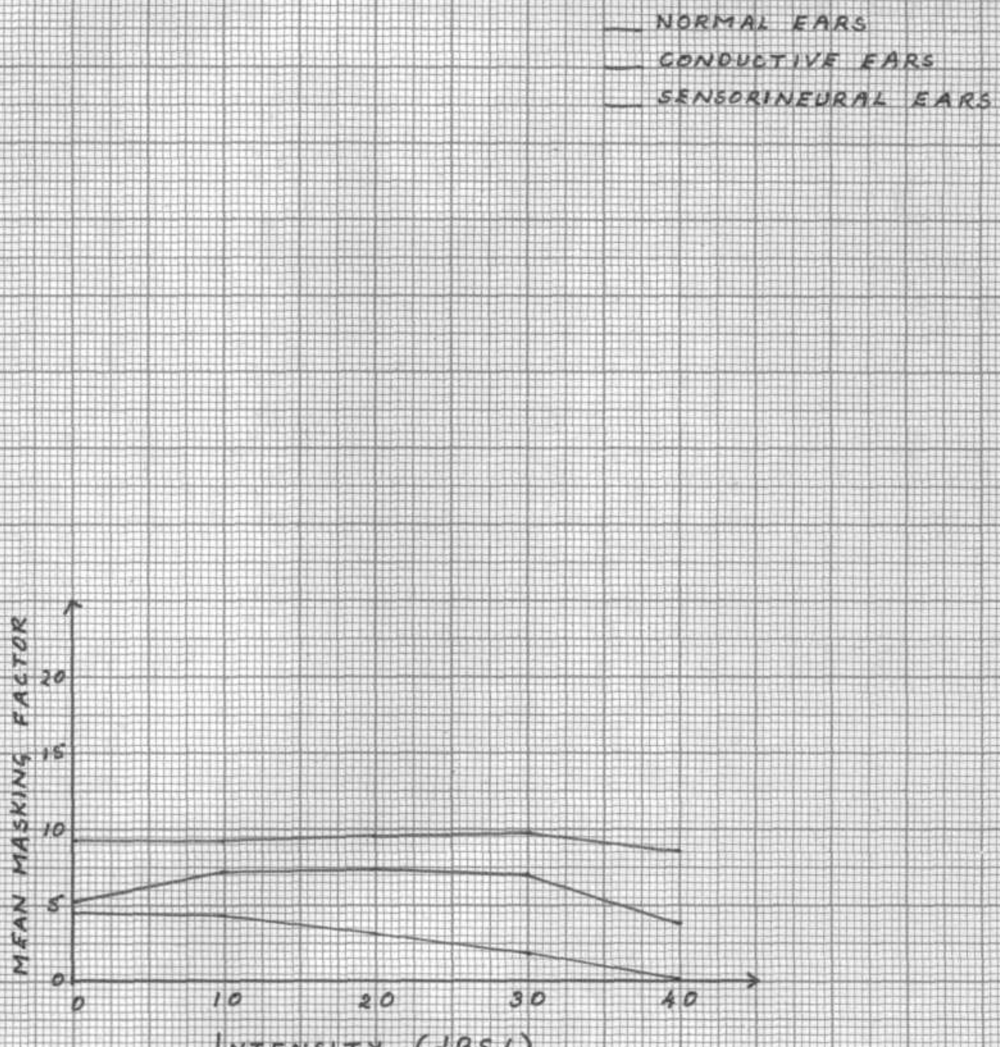
Intensity	0 dBSL	10 dBSL	20 dBSL	30 dBSL	40 dBSL
0 dBSL			---	-	0
10 dBSL		-		-0	
20 dBSL				--	
30 dBSL					-
40 dBSL					

0 Significant at 0.05 level.
+ Significant at 0.01 level.
- Not significant.

Table 4.5: Showing the significance of difference between mean values of Masking Factor across various intensities in ears with sensori neural hearing loss at 4000 Hz.

Intensity	0 dBSL	10 dBSL	20 dBSL	30 dBSL	40 dBSL
0 dBSL		--			0
10 dBSL			-	- -	
20 dBSL				- -	
30 dBSL					-
40 dBSL					

0 Significant at 0.05 level.
+ Significant at 0.01 level.
- Not significant.



GRAPH 4.1(d): A COMPARISON OF THE MEAN VALUES OF MASKING FACTOR ACROSS VARIOUS INTENSITIES, AT 2000 Hz.

Table 4.6: Showing the signficance of difference between mean values of Masking Factor across various intensities in ears with conductive hearing loss at 2000 Hz.

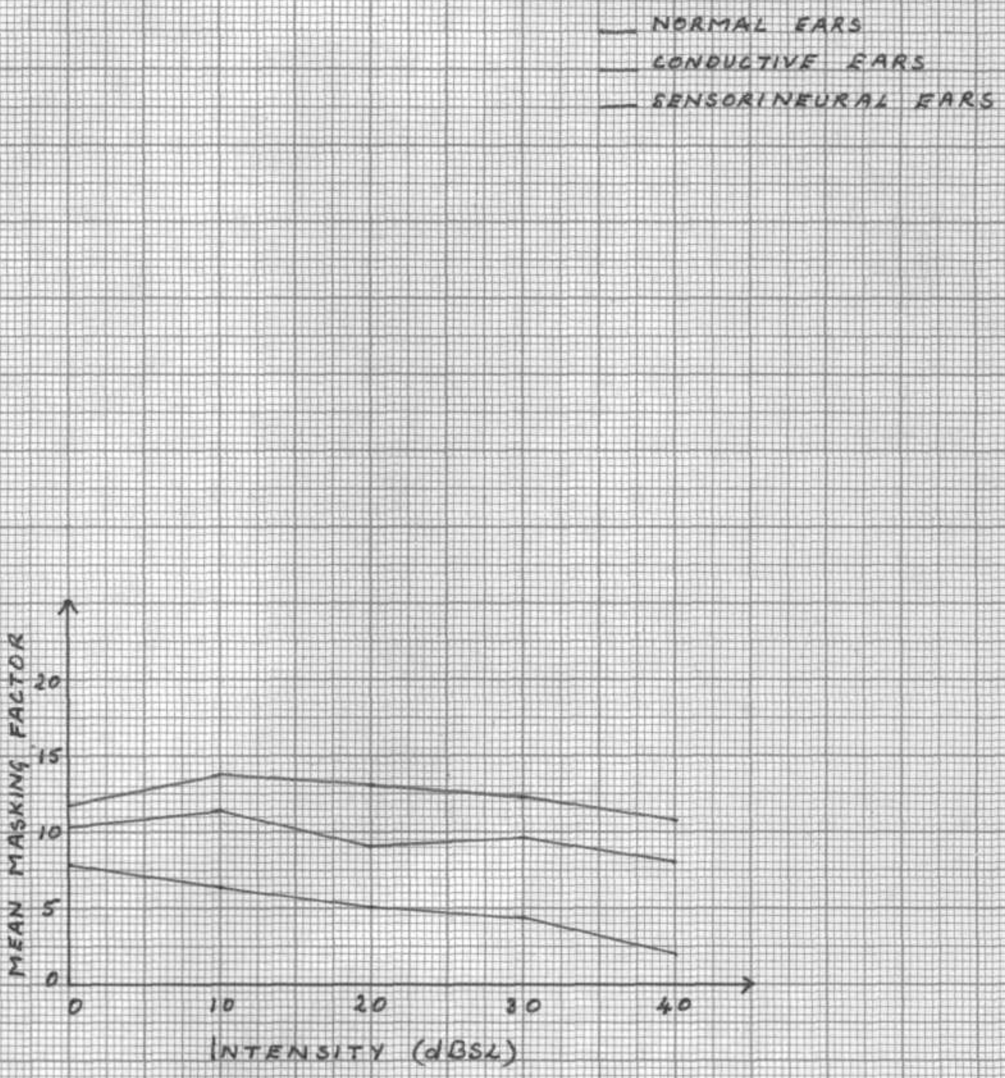
Intensity	0 dBSL	10 dBSL	20 dBSL	30 dBSL	40 dBSL
0 dBSL		--		--	
10 dBSL				-0	
20 dBSL				-0	
30 dBSL					-
40 dBSL					

0 Significant at 0.05 level.

\+ Significant at 0.01 level.

\- Not significant.

NOTE: The tables showing the significance of difference between mean values of Masking Factor across various intensities in normal ears and ears with conductive and sensori neural hearing loss at frequencies other than 2000 Hz and 4000 Hz, have not been presented here, as no significant difference was obtained.



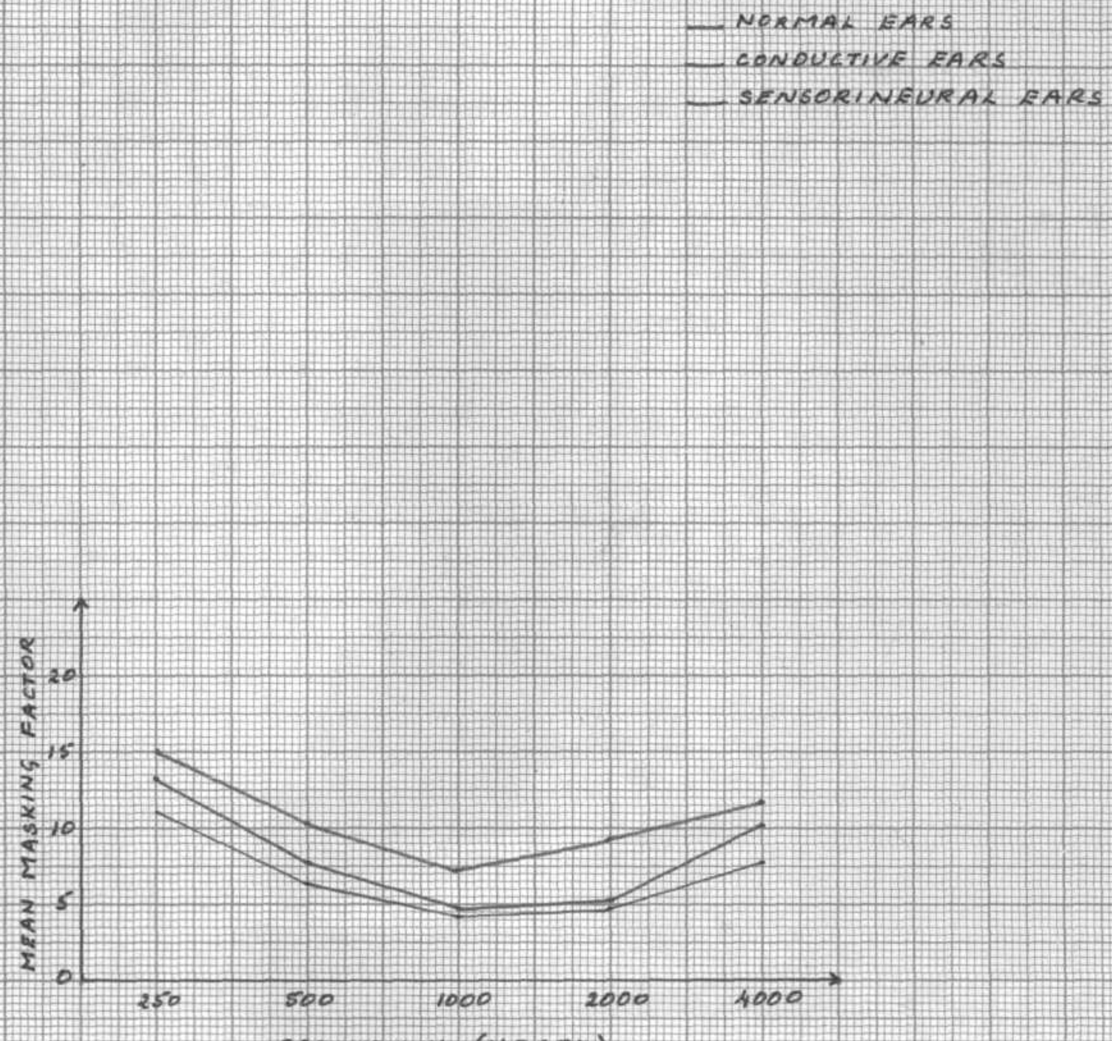
GRAPH 4.1(e): A COMPARISON OF THE MEAN VALUES OF MASKING FACTOR ACROSS VARIOUS INTENSITIES, AT 4000 Hz.

To study the variation in masking factor across frequencies, the mean and standard deviation were computed for all the frequencies at each intensity level. Table 4.7 provides the values in ears with normal hearing. Similar data are provided in Table 4.8 and Table 4.9 for ears with conductive pathology and ears with sensori neural pathology respectively. For an understanding of the difference in the masking factor across frequencies, the significance of mean difference test was applied between the means of the frequencies at each intensity level. The results are indicated in Table 4.10 (a-e) for normal ears, Table 4.11 (a-e) for ears with conductive hearing loss and Table 4.12 (a-e) for ears with sensori neural hearing loss.

In normal ears a significant difference (significant at 0.01 level) was found between 250 Hz and 1000 Hz and also between 250 Hz and 2000 Hz at all the five intensity levels. Between 250 Hz and 500 Hz the difference in mean values was significant at all levels except 40 dBSL. However, between 250 Hz and 4000 Hz, there was no significant difference in the mean values at all the frequencies studied. The mean values of 500 Hz differed significantly from those of 1000 Hz at all the five levels. However, there was no significant difference in the mean values of 500 Hz with 2000 Hz or 4000 Hz. A significant difference between 1000 Hz and 2000 Hz was observed at threshold

Table 4.7: Mean and Standard Deviation of the Masking Factor at various frequencies in normal hearing ears.

Frequency	No.of Ears Mean S.D.	Intensity in dBSL				
		0	10	20	30	40
250 Hz	N	20	20	20	20	14
	$\bar{x}$	15.000	16.000	16.000	15.250	14.643
	σ	5,620	5.026	5.282	6.172	10.463
500 Hz	N	20	20	20	20	20
	$\bar{x}$	10.250	11.000	11.000	11.500	11.750
	σ	3.432	3.839	4.168	4.894	5.911
1000 Hz	N	20	20	20	20	20
	$\bar{x}$	7.250	7.500	7.500	7.750	7.500
	σ	3.024	3.035	3.804	3.432	3.035
2000 Hz	N	20	20	20	20	20
	$\bar{x}$	9.250	9.250	9.500	9.750	8.500
	σ	2.447	2.447	3.591	3.796	4.617
4000 Hz	N	20	20	20	20	20
	$\bar{x}$	11.750	13.750	13.000	12.250	10.750
	σ	6.340	6.043	6.156	6.973	7.304

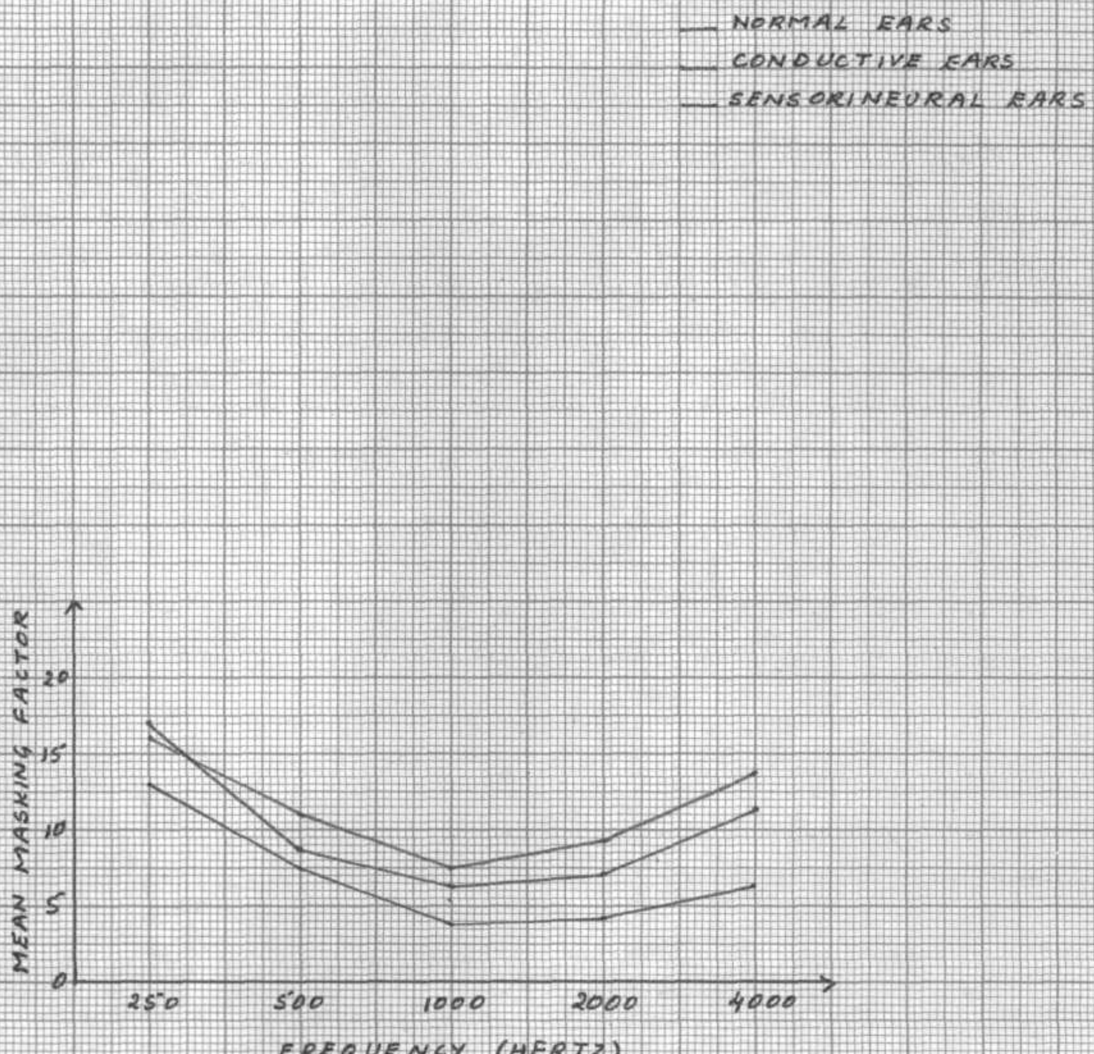


GRAPH 4·2(a): A COMPARISON OF THE MEAN VALUES OF MASKING FACTOR ACROSS VARIOUS FREQUENCIES, AT 0dBSL.

Table 4.8: Mean and Standard Deviation of the Masking Factor at various frequencies in ears with conductive pathology.

Frequency	No.of Ears Mean S.D.	Intensity in dBSL				
		0	10	20	30	40
250Hz		15	7	5	13	CNE
	$\bar{x}$	13.333	17.143	12.000	13.333	CNE
	σ	3.086	9.512	4.472	2.887	CNE
500 Hz	N	18	16	12	9	6
	$\bar{x}$	7.778	8.750	7.083	7.222	7.500
	σ	3.078	4.655	3.343	3.632	2.739
1000 Hz	N	18	18	16	10	9
	$\bar{x}$	4.722	6.389	4.688	4.500	5.556
	σ	3.196	4.132	3.400	3.689	5.270
2000 Hz		18	18	17	15	9
	$\bar{x}$	5.278	7.222	7.353	7.000	3.889
	σ	2.081	3.524	3.999	4.551	3.333
4000 Hz		18	17	17	14	8
	$\bar{x}$	10.278	11.471	9.118	9.642	8.125
	σ	5.809	5.800	6.900	6.924	8.839

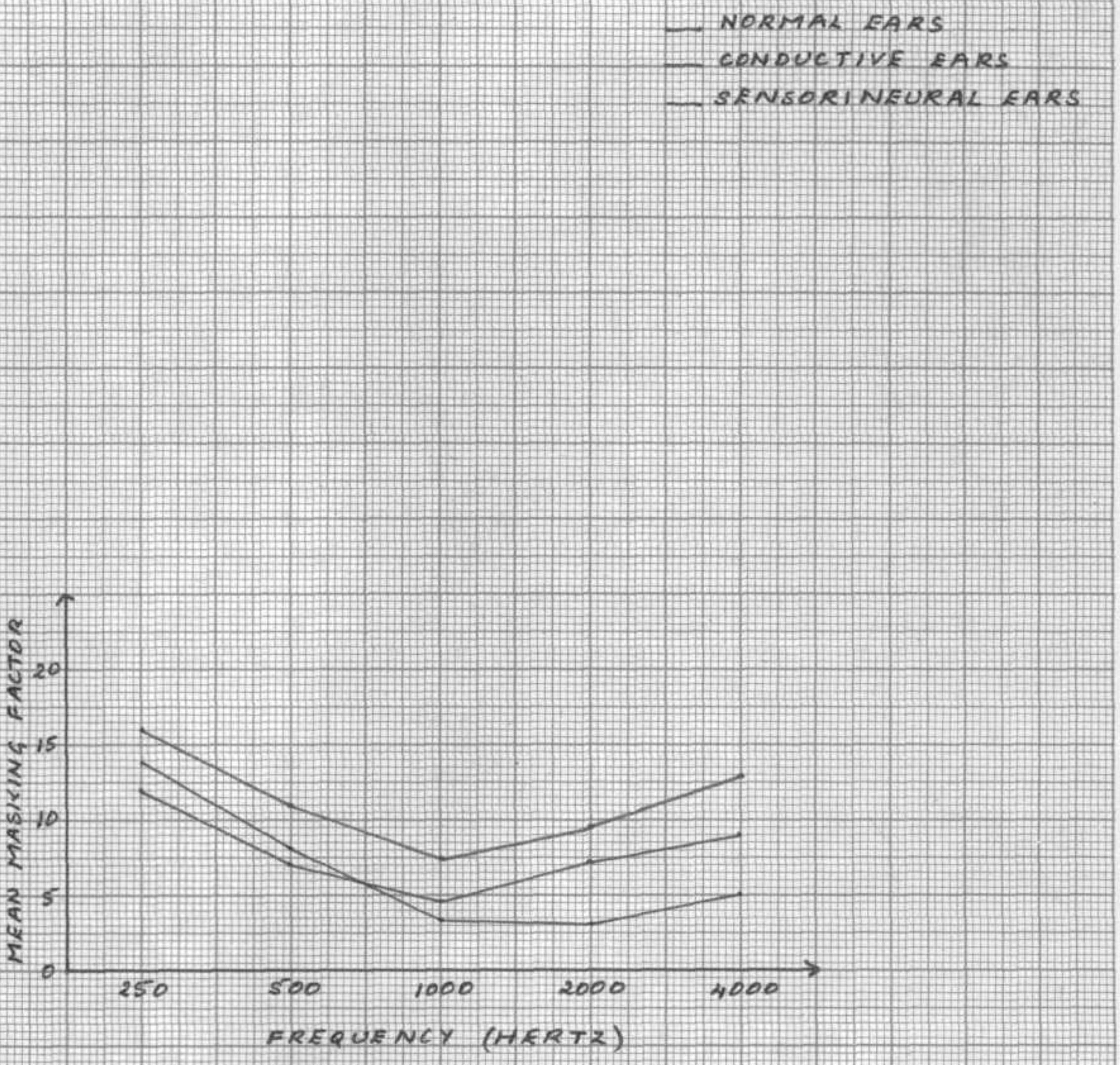
CNE = could not be established.



GRAPH 4·2(b): A COMPARISON OF THE MEAN VALUES OF MASKING FACTOR ACROSS VARIOUS FREQUENCIES, AT 10dBSL.

Table 4.9: Mean and Standard Deviation of the Masking Factor at various frequencies in ears with sensori neural pathology.

Frequency	No.of Ears Mean S.D.	Intensity in dBSL				
		0	10	20	30	40
250 Hz	N	14	13	9	3	3
	$\bar{x}$	11.071	13.077	13.889	8.333	8.333
	σ	4.463	4.804	5.465	2.887	2.887
500 Hz	N	14	14	13	12	8
	$\bar{x}$	6.429	7.500	8.077	7.917	7.500
	σ	2.344	3.798	5.220	5.823	5.345
1000 Hz	N	14	14	13	13	8
	$\bar{x}$	4.286	3.929	3.462	2.308	-0.625
	σ	3.315	3.496	4.274	5.250	9.039
2000 Hz		14	14	14	11	9
	$\bar{x}$	4.643	4.286	3.214	1.818	0
	σ	3.079	3.315	3.725	5.135	5.000
4000 Hz	N	14	14	12	9	5
	$\bar{x}$	7.857	6.429	5.000	4.444	2.000
	σ	4.258	5.345	4.264	5.270	5.701



GRAPH 4·2 (c): A COMPARISON OF THE MEAN VALUES OF MASKING FACTOR ACROSS VARIOUS FREQUENCIES, AT 20dBSL.

Table 4.10(a): Showing the significance of difference between mean values of Masking Factor across various frequencies in normal ears

Frequency	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
250 Hz		+	+	+	-
500 Hz			+	-	-
1000 Hz				0	+
2000 Hz					—
4000 Hz					

0 Significant at 0.05 level

+ Significant at 0.01 level

- Not significant.

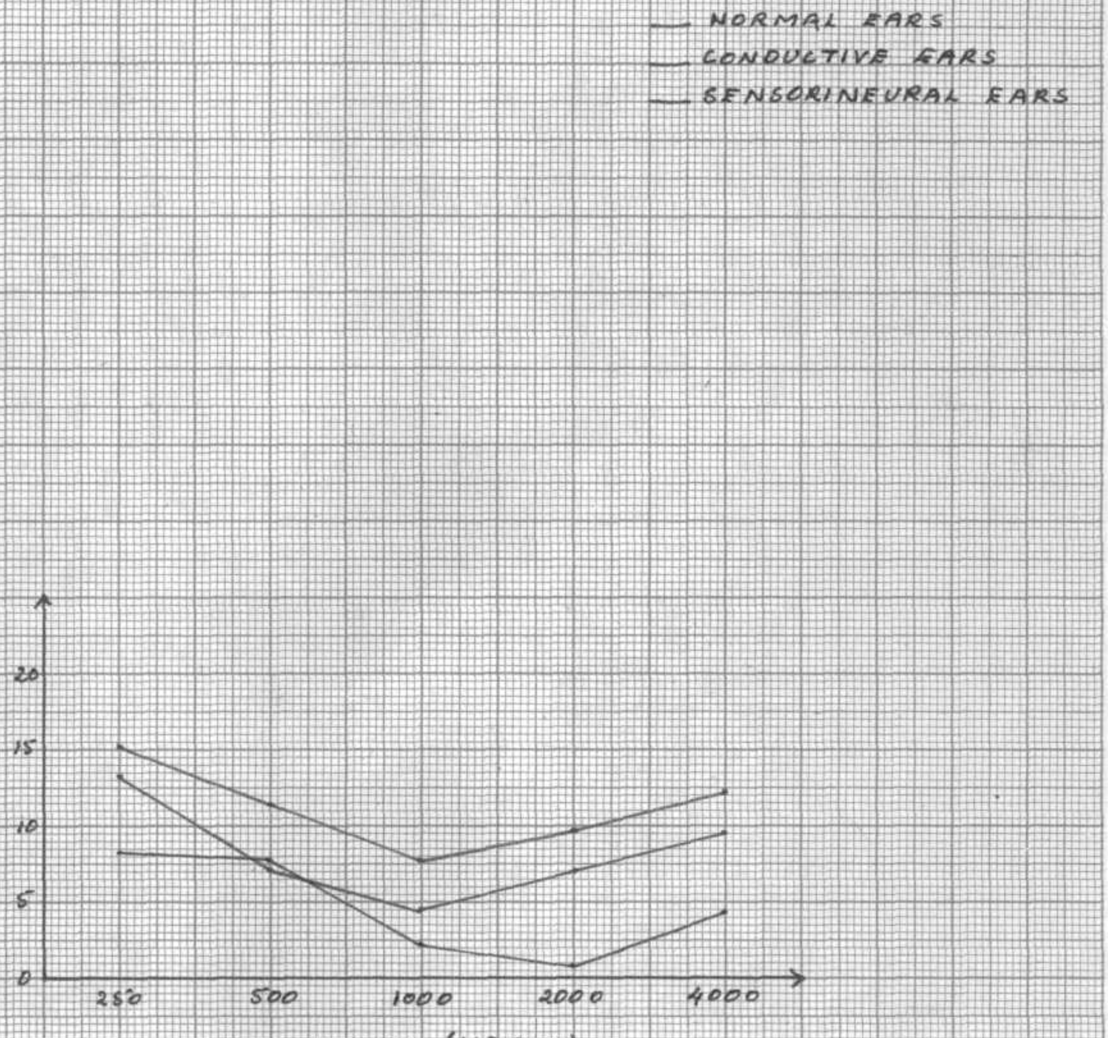
Table 4.10(b): Showing the significance of difference between mean values of Masking factor across various frequencies in normal ears at 10 dBSL.

Frequency	250 Hz	500Hz	1000 Hz	2000 Hz	4000 Hz
250 Hz		+	+	+	-
500 Hz			'+	-	-
1000 Hz					
2000 Hz					+
4000 Hz					

0 Significant at 0.05 level

+ Significant at 0.01 level.

- Not significant.



GRAPH 4·2(d): A COMPARISON OF THE MEAN VALUES OF MASKING FACTOR ACROSS VARIOUS FREQUENCIES, AT 30dBSL

Table 4.10(c): Showing the significance of difference in the mean values of Masking Factor across various frequencies in normal ears at 20 dBSL.

Frequency	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
250 Hz		+	+	+	-
500 Hz			+	-	-
1000 Hz					
2000 Hz					0
4000 Hz					

0 Significant at 0.05 level.

\+ Significant at 0.01 level.

\- Not significant.

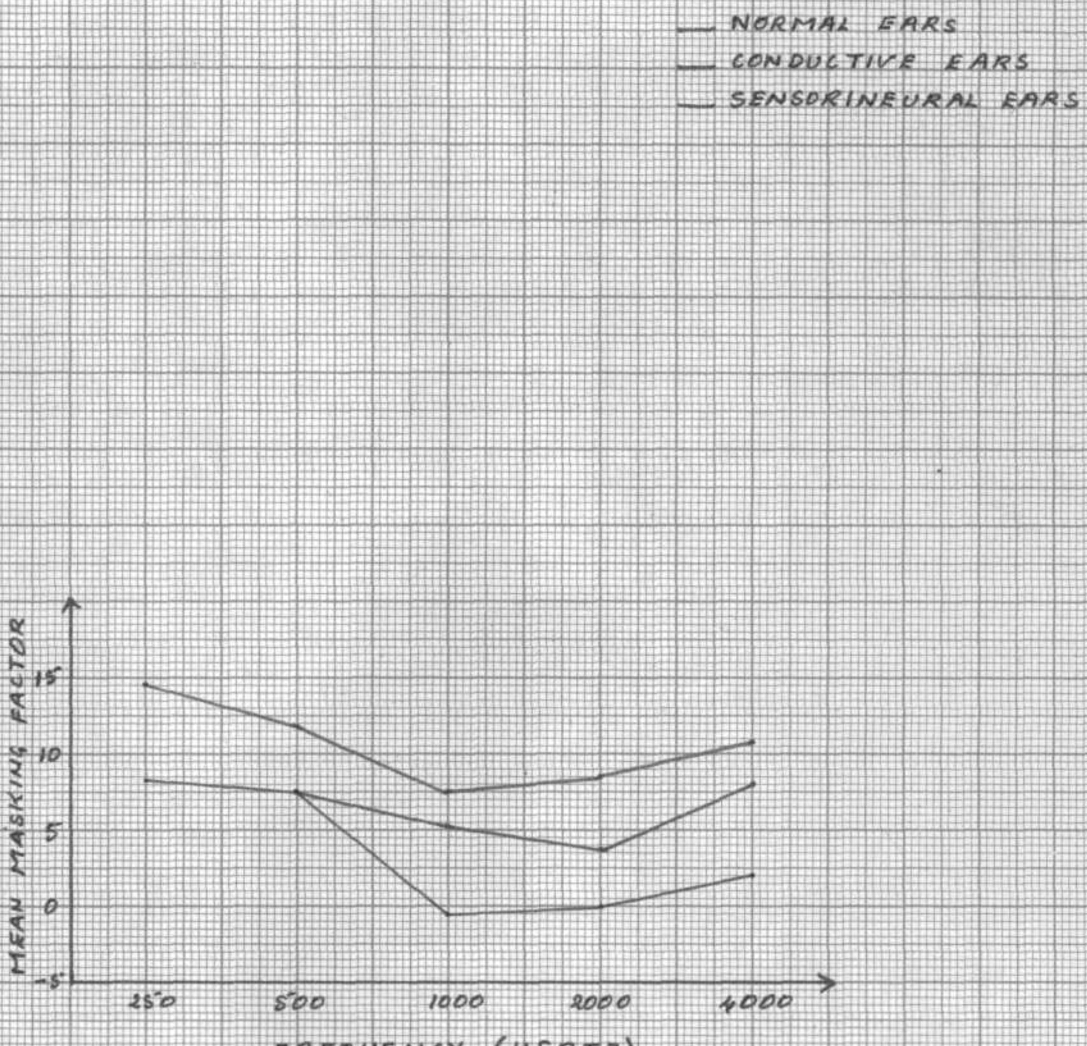
Table 4.10(d): Showing the significance of difference in the mean values of Masking Factor across various frequencies in nroaml ears at 30 dBSL.

Frequency	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
250 Hz		0	+	+	
500 Hz			+	-	-
1000 Hz				-	0
2000 Hz					
4000 Hz					

0 Significant at 0.05 level

\+ Significant at 0.01 level.

\- Not significant.



GRAPH 4·2(e): A COMPARISON OF THE MEAN VALUES OF MASKING FACTOR ACROSS VARIOUS FREQUENCIES, AT 40dBSL.

Table 4.10(e): Showing the significance of difference in the mean values of Masking Factor across various frequencies in normal ears at 40 dBSL.

Frequency	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
250 Hz			+ 0 0		
500 Hz			+ - -		
1000 Hz			- -		
2000 Hz			-		
4000 Hz					

0 significant at 0.05 level

\+ significant at 0.01 level.

\- not significant

Table 4.11(a): Showing the significance of difference in the mean values of Masking Factor across various frequencies in ears with conductive hearing loss at 0 dBSL.

Frequency	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
250 Hz		+ + + -			
500 Hz		- - -			
1000 Hz		- 0			
2000 Hz					0
4000 Hz					

0 significant at .05 level.

\+ significant at .01 level.

\- not significant

Table 4.11(b): Showing the significance of difference between mean values of Masking Factor across various frequencies in ears with conductive hearing loss at 10 dBSL.

Frequency	250 Hz	500Hz	1000 Hz	2000 Hz	4000Hz
250 Hz		+	+	+	+
500 Hz			0	0	-
1000 Hz				--	
2000 Hz					-
4000 Hz					

0 significant at 0.05 level

+ significant at 0.01 level.

- not significant

Table 4.11(c): Showing the significance of difference between mean values of Masking Factor across various frequencies in ears with conductive hearing loss at 20 dBSL.

Frequency	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
250 Hz		0	+	+	+
500 Hz			0	+	—
1000 Hz				--	
2000 Hz					-
4000 Hz					

0 significant at 0.05 level

+ significant at .01 level

- not significant

Table 4.11(d): Showing the significance of difference in the mean values of Masking Factor across various frequencies in ears with conductive hearing loss at 30 dBSL.

Frequency	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
250 Hz		—	—	—	—
500 Hz			0	0	-
1000 Hz					
2000 Hz					
4000 Hz				-- -	

0 significant at 0.05 level

\+ singificant at 0.01 level.

\- not significant

Table 4.11(e): Showing the significance of difference in the mean values of Masking Factor across various frequencies in ears with conductive hearing loss at 40 dBSL.

Frequency	250 Hz	500Hz	1000 Hz	2000 Hz	4000 Hz
250 Hz		-	-	0	-
500 Hz			0	+	-
1000 Hz	--				
2000 Hz	-				
4000 Hz					

0 significant at 0.05 level

\+ significant at 0.01 level.

\- not significant

level (0 dBSL) only. The mean values between 1000 Hz and 4000 Hz differed significantly at 0 dBSL and 30 dBSL. Between 2000 Hz and 4000 Hz, a significant difference in the masking factor was present at 10 dBSL and 30 dBSL. Hence hypothesis IV) was rejected, as is evident from the discussion above.

In ears with a conductive component also, a difference in the mean Masking Factor values were observed, across frequencies. A significant difference was observed between 250 Hz and 500 Hz and between 250 Hz and 2000 Hz at 0 dBSL, 10 dBSL and 20 dBSL as indicated in Table 4.11 (a-e). However, between 250 Hz and 2000 Hz, the values were significant at all levels except 30 dBSL, whereas between 250 Hz and 4000 Hz, it was significant only at 10 dBSL and 20 dBSL. The mean values at 500 Hz differ significantly from those at 1000 Hz and 2000 Hz at all the levels, exclusive of threshold level. However, the reverse was true with the masking factor at 1000 Hz and 2000 Hz, wherein it differed from that at 4000 Hz only at threshold level. The Hypothesis V, stating that there is no significant difference between the masking factor values at different frequencies, was rejected.

An examination of the Tables 4.i2(a-e) reveals the significance of the difference in the mean values of the masking factor at different frequencies in the sensori neural hearing loss ears. There was a significant difference in the mean values between 250 Hz and all other frequencies except 4000 Hz, at all the levels. A significant difference between 500 Hz and 1000 Hz was observed at 0 dBSL and between 500 Hz and 2000 Hz at 0 dBSL and 40 dBSL. The mean at 1000 Hz differed significantly from the mean at 2000 Hz only at 20 dBSL, but differed significnatly from the mean at 4000 Hz at all levels except 40 dBSL. A significant difference in the mean masking factor was obtained at 0 dBSL and 10 dBSL between 2000 Hz and 4000 Hz. These results lead to the rejection of Hypothesis VI. The Graphs 4.2 (a-e) present a better picture of the difference in the mean masking factor values across frequencies. It further provides a comparison of the values between the three types of ears studied, namely the ears with normal hearing, conductive loss and ears with sensori neural hearing loss.

To test (1) hypothesis VII, which states that there is no significant difference in the masking factor between the normal and conductive loss ears (2) hypothesis VIII, which states that there is no significant difference in the masking factor between normal and sensori neural hearing loss ears and (3) hypothesis IX, which states

Table 4.12(a): Showing the significance of difference in mean values of Masking Factor across various frequencies in ears with sensori neural hearing loss at 0 dBSL.

Frequency	250 Hz	500 Ha	1000 Hz	2000 Hz	4000 Hz
250 Hz		+	+	+	-
500 Hz			*	+	-
1000 Hz				+	-
2000 Hz					
4000 Hz				+	

0 significant at 0.05 level.

+ significant at 0.01 level.

- not significant

Table 4.12(b): Showing the significance of difference in mean values of Masking Factor across various frequencies in ears with sensori neural hearing loss at 10 dBSL.

Frequency	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
250 Hz		+	+	+	
500 Hz		--			-
1000 Hz				-	+
2000 Hz					0
4000 Hz					

0 significant at 0.05 level

+ singificant at 0.01 level.

- not significant

Table 4.12(c): Showing the significance of difference in the mean values of Masking Factor at various frequencies in ears with sensori neural hearing loss at 20 dBSL.

Frequency	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
250 Hz		0	+	0	-
500 Hz			-	-	-
1000 Hz				0	0
2000 Hz					-
4000 Hz					

0 Significant at 0.05 level

\+ Significant at 0.01 level.

\- Not significant

Table 4.12(d): Showing the significance of difference in the mean values of Masking Factor at various frequencies in ears with sensori neural hearing loss at 30 dBSL.

Frequency	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
250 Hz		0	+	0	-
500 Hz			-	-	-
1000 Hz				-	0
2000 Hz					-
4000 Hz					

0 significant at 0.05 level

\+ significant at 0.01 level.

\- Not significant

Table 4.12(e): Showing the significance of difference in mean values of Masking Factor across various frequencies in ears with sensori neural hearing loss at 40 dBSL.

Frequency	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
250 Hz		CNE	CNE	CNE	CNE
500 Hz			-	0	-
1000 Hz				-	-
2000 Hz					-
4000 Hz					

CNE = could not be established.

0 significant at 0.05 level.

\+ significant at 0.01 level.

\- Not significant

that there is no significant difference in masking factor between conductive and sensori neural hearing loss ears, the following procedure was undertaken. Since no significant difference was observed between the means of the masking factor at different intensity levels, one level dBHL/dBSL 30 dBSL (Martin recommends 30 dBHL for finding the masking factor) was selected. The average masking factor of 500 Hz, 1000 Hz and 2000 Hz at 30 dBSL was found for ears with normal hearing. A similar average was computed for ears with conductive pathology and ears with sensori neural pathology. The mean and standard deviation values are provided in Table 4.13 and the mean values have been shown graphically in graph 4.3. To check whether a significant difference exists between normal, conductive and sensori neural hearing loss ears with respect to the masking factor, the t-test of significance was applied. The results are indicated in Table 4.14. A significant difference at 0.01 level was obtained between normal and conductive loss ears, thereby rejecting hypothesis VIII. A significant difference was also found between normal ears and ears with sensori neural hearing loss. Hypothesis VIII, therefore, was also rejected. However, a significant difference was not observed between the ears with conductive pathology and the ears with sensori neural pathology at both 0.05

and 0.01 levels of significance. This may probably be due to a sampling error, individual differences or due to the fact that only a small sample was studied; as the difference was found to be significant at 0.1 level. The differences are evident in Graph 4.3. From the results obtained here, hypothesis IX was accepted, which states that there is no significant difference in the masking factor between conductive loss ears and sensori neural loss ears.

The rejection of Hypothesis VII and VIII, support the point raised by Veniar (1965) that the noise constituting effective masking in a normal ear cannot be extrapolated to an ear with loss. Denes and Naunton (1952) and Zwislocki (1951) have pointed out that the very pattern of loss, changes the quality and effectiveness of the white noise.

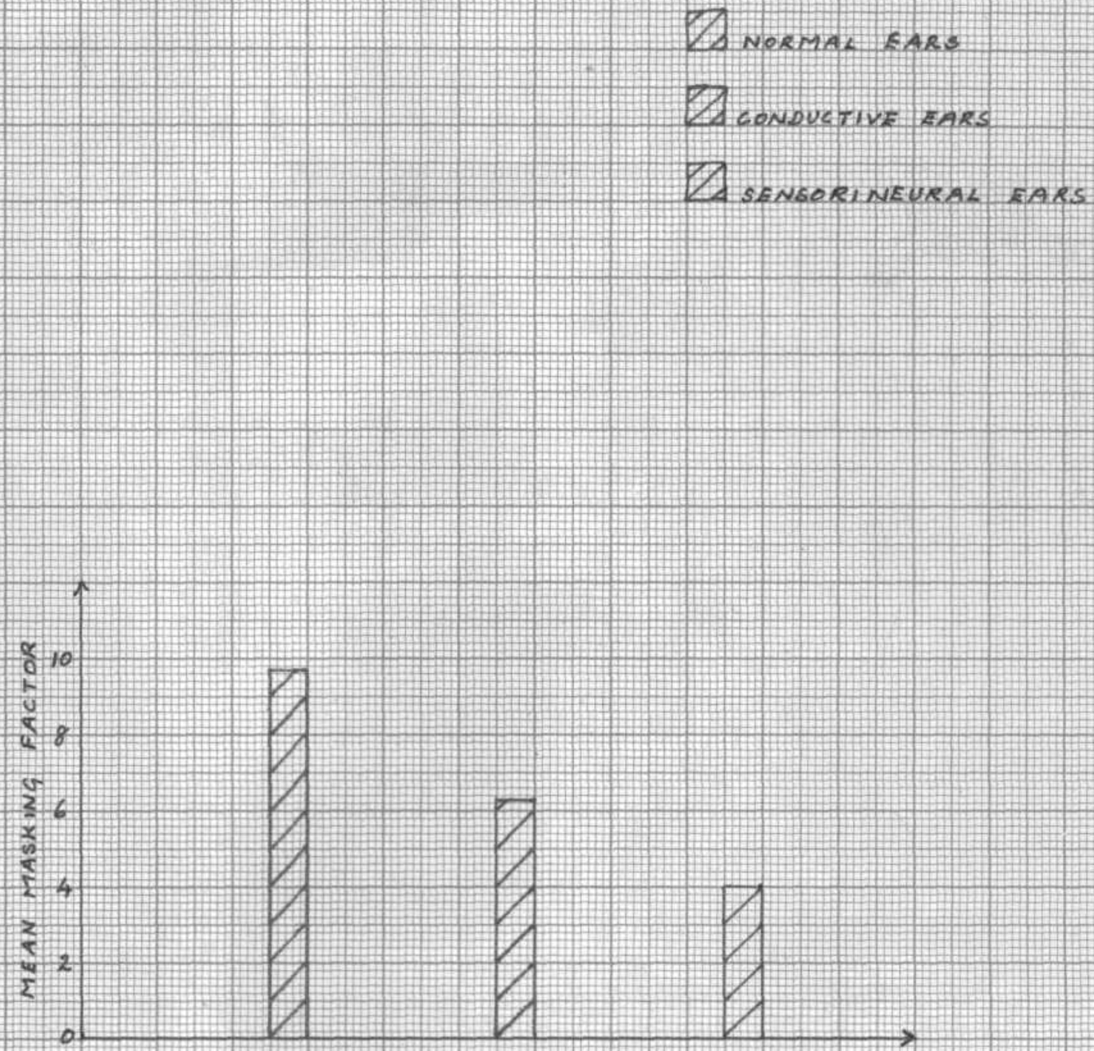
The results indicate that the relationship between the masking dial setting and the amount of effective masking must be determined for each audiometer across all frequencies for the various types of pathologic ears. Veniar (1965) has further criticised the common clinical practise of establishing the minimum masking level norms for each masker. She points out that individual subjects

Table 4.13: Mean and Standard Deviation of Masking Factor of the average of 500 Hz, 1000 Hz and 2000 Hz at 30 dBSL in normal ears and ears with conductive and sensori neural hearing loss.

Ears	N	$\bar{x}$	
Normal	60	9.667	4.304
Conductive	34	6.324	4.139
Sensori neural	36	4.027	5.955

Table 4.14: Showing the significance of difference between mean values in normal ears and ears with conductive and sensori neural components.

Ears	Normal	Conductive	Sensori neural
Normal		3.67	5.37
Conductive			1.86
Sensori neural			-



GRAPH 4·3: A COMPARISON OF THE AVERAGE MASKING FACTOR (500 Hz, 1000 Hz AND 2000 Hz) IN NORMAL, CONDUCTIVE AND SENSORINEURAL EARS, AT 30 dBSL.

deviate considerably from normative standards. The present study also, found considerable individual differences in the masking factor. Differences of as much as 25 dB were observed at some levels. This could result in an increasing probability of under-masking or overmasking in many cases, ultimately leading the audiologist to an erroneous diagnosis. Veniar (1965), has therefore, recommended a more valid procedure of establishing the minimum masking levels for each subject at each frequency. However, this testing procedure would be tedious, both for the subject being tested and for the audiologist. Hence, it is suggested herein, that for more reliable test results and a valid diagnosis, it is essential to find the masking factor across frequencies in different pathologic ears. This determination must be made before the audiometer is put into use and periodically thereafter.

CHAPTER 5

SUMMARY AND CONCLUSIONS

Modern audiological assessment is based on Pure Tone Audiometry (Lloyd, 1975), and Masking is often employed in the routine audiometric test procedure.

Clinical Masking is one of the most complex audiometric procedures to understand and to execute. It is complex because it involves so many variables that operate simultaneously, some of them under very tenuous control (Ventry, 1971).

The purpose of the present investigation was to study one such variable, namely, "Masking Factor". Informed use of masking in audiometry requires that the clinician know the hearing level to which the non test ear is shifted by the masking noise.

This study was an attempt at comparing the masking factor in normal ears and pathologic ears. Further a comparison of the Masking Factor was made across five intensity levels (0 dBSL, 10 dBSL, 20 dBSL, 30 dBSL and 40 d3SL), and across five frequencies (250 Hz, 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz) in both the normal ears and the pathologic ears.

A sample of twenty ears with normal hearing (ANSI, 1969), eighteen ears with mild or moderate conductive hearing loss and fourteen ears with mild or moderate sensori neural hearing loss were selected for the study. All the subjects were adults. Pulsed pure tone thresholds were established for each of these subjects at frequencies 250 Hz, 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz using the Hughson Westlake procedure (Green, 1978). Following this, pulsed pure tones were presented at five different intensity levels (0 dBSL, 10 dBSL, 20 dBSL, 30 dBSL and 40 dBSL) at each of the five frequencies. Simultaneously narrow band noise was presented continuously through the same earphone. The level of noise required to just mask the pulsed pure tones were determined. The masking factor for each intensity, at each frequency was then determined by subtracting the tone level from the noise level.

The data thus obtained was subjected to statistical analysis. The results indicated a significant difference in the masking factor between the normal ears and ears with conductive hearing loss and also between normal ears and ears with sensori neural hearing loss, (significant at 0.01 level). However, no significant difference was obtained between ears with conductive hearing loss and ears with sensori neural hearing loss (significant at 0.1 level).

The difference in masking factor was not significant across the five intensity levels (0 dBSL, 10 dBSL, 20 dBSL, 30 dBSL and 40 dBSL) in both the normal and pathologic ears (both conductive and sensori neural hearing loss).

However, a significant difference in the mean values were obtained between the various frequencies. The differences were more pronounced with 250 Hz and 500 Hz in all the ears tested.

Implications of the study:

In routine clinical masking procedures, it becomes necessary to obtain the masking factor for different pathologic conditions at each frequency, prior to using the audiometer. It is therefore, necessary to incorporate these values, rather than employ the values obtained on normal hearing subjects, for all the ears, whether normal or pathologic, as is being practised presently. Coupled with the knowledge of interaural attenuation, this information permits assurance that cross over is not occurring.

Limitations of the study:

The study was conducted on a small population.

Further, the age of the subjects and the degree of hearing loss, whether mild or moderate, were not considered as significantly different.

Recommendations:

1. The present study may be tried on a larger population.
2. An attempt may be made to study the Masking Factor across various age groups.
3. The study may be carried out taking into consideration the various degrees of hearing loss.
4. A similar study may be conducted using reterocochlear pathology cases.
5. The Masking Factor in normal and pathologic ears may be studied using different types of noise.

APPENDIX

Definitions of Terms Used.

Effective Masking Level:

The number of dB that the total energy in the i initial band is above the threshold energy for a pure tone whose frequency is at the centre of the band. It is also regarded as the threshold shift in dB produced in the masked ear by a given amount of noise.

Masking:

The elevation in threshold for one signal (the test tone) by the presence of a second signal (the masking noise). The former is referred to as the Maskee and the latter as the Masker.

Masking Factor:

The difference between the noise level and tone level, in dBHL.

Minimum Masking_Level:

The noise level in the nontest ear which is just sufficient to mask the test signal in the non test ear (masked ear).

Narrow Band Noise:

It is a restricted band of frequencies surrounding a particular frequency and is obtained by band-pass filtering broad band noise. The signal is continuous within the frequency band, and intensity is essentially equal across the band.

Pulsed Pure Tone:

A pure tone which has a 50 msec rise-decay time and 200 msec duration. The inter stimulus duration is 1.5 seconds.

Pure Tone:

A tone of only one frequency.

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