MAXIMUM EFFECTIVE MASKING LEVELS IN NORMAL & PATHOLOGICAL EARS

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A Dissertation submitted in part fulfillment for the Degree of Master of Science (Speech & Hearing)

University of Mysore

1984

C E R T I F I C A T E

This is to certify that the Disseration entitled "THE MAXIMUM EFFECTIVE MASKING LEVELS IN NORMAL & PATHOLOGICAL EARS" is the bonafide work in cart fulfilment for the Degree of Master of Science (Speech & Hearing) of student with Register No. 3

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CERTIFICATE

This is to certify that this Dissertation has been done under my supervision and guidance.

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CONTENTS

D E C L A R A T I O N

This Dissertation entitled "THE MAXIMUM EFFECTIVE MASKING LEVELS IN NORMAL & PATHOLOGICAL EARS" is the result of my own study under the guidance of Dr. M.N. Vyasamurthy, Lecturer in Audiology and has not been submitted earlier at any University or Institution for any other Diploma or Degree.

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ACKNOWLEDGEMENT

I thank my guide Dr. M.N Vyasamurthy, for his valuable guidance throughout the study.

I also thank:

Dr. N. Rathna and Dr.(Miss) Shailaja Nikam for giving me an opportunity to do this Dissertation.

Mr. S.S.Murthy, Mr. Narayan Raju, Miss Chudamani & Mrs. Jayashree for their helD in the calibration of the instruments.

Mr. Balakrishna, Mrs. Prema, Dr. Vishuanath and many others for taking pains in getting me the subjects.

My friends Usa, Sue, Latha & Kat for their help and support.

My Subjects for their kind co-operation.

Mrs. Parimala for bring this out in a neat form.

C O N T E N T S

CHAPTERS

CHAPTER-1

INTRODUCTION

Clinical masking has been one of the long debated topics in audiology. With the increasing demand for accurate audiological diagnosis, the dependancy on masking is increasing.

Masking is the process in Mhich the elevation of one signal occurs in the presence of a second signal. (Ventry, 1971). Masking is used either to denote the threshold shift per se or the amount by Mhich threshold is raised. (Beagley, 1981). Masking is done to isolate thresholde nontest ear so as to avoid the contamination of results or to find out the patient's understanding of speech in noise (Beagley, 1981). In threshold testing, masking is executed to find out the accurate sensitivity of subjects ears. Masking in audiometry appears to be complicated due to the involvement of several factors viz., presentation level of the tone, the interaural attenuation, the occlusion effect, the a-b gap, the masking factor, undermasking, overmasking, etc. (Vyasamurthy, 1970).

There are many factors to be considered for employing masking in a satisfactory May. Staab has identified six areas of discussion for clear understanding of masking; definition of terms; purpose of the use; type of stimuli, when to employ masking, correct use of levels and procedures of masking. (Goldstein, 1979).

In threshold audiometric tasting, once the need for masking is recognized, the nontest ear is introduced with narrow band masking noise, with the Dure tone threshold estimation process going on in the test ear. Studies have shown that inappropriate levels of masking might be more dangerous than not masking at all. So, the knowledge of maximum and minimum masking levels is a must for audiologists.

Maximum effective masking level is defined as the intensity just insufficient to mask the test signal in the test ear (Studebaker, 1967). The exact maximum masking level needs to be known for two purposes:

(1) to get the real thresholds of the test ear.

(2) to avoid the chances of overmasking.

NEED FOR THE STUDY:-

While deciding the maximum effective masking levels, it is generally assumed that if the noise level (in dBEL) in the nontest ear exceeds the sum of the bone conduction threshold of the test ear and the interaural attention, the problem of over-masking results.

It is necessary for the audiologists to know both the minimum effective masking levels and the maximum effective masking levels required for the subject, at the test frequency before masking is attempted. Since the audiologists mainly depend on the formula (Maximum effective masking level - B C threshold of the test ear + interaural attenuation) to decide the maximum level of the noise, a question arises regarding the validity of the formula in different clinical populations. From the available literature, it appears that studies verifying the validity of maximum masking formula on clinical populations are scanty or perhaps not carried out at all. (at least on the lines of the present investi-gations).

With the above view in mind, the present study has been designed to verify whether the obtained maximum effective masking levels agree with the predicted (calculated) maximum effective masking levels. The following null hypotheses has been made;

(1) There is no significant difference between the obtained mean maximum effective masking levels and the predicted (calculated) mean maximum effective masking levels in conductive loss group.

(2) There is no significant difference between the obtained mean maximum effective masking levels and the predicted (calculated) mean maximum effective masking levels in sensori-neural loss group.

C H A P T E R - II

REVIEW OF LITERATURE

Of all the clinical procedures used in auditory assessment, masking seems to be the least understood and Misused, producing a greatest degree of insecurity. The lack of basic tenets of masking causes it to be conducted with lack of scientific accuracy (Martin, 1980). For some clinicians, the approach to masking is a hapazard, hit-or-miss, bit of guess work with no set principles. Mow that the audiological testing has become an important diagnostic tool for both surgeon and clinician, information about masking is of utmost importance. (Winchester, 1968). The increasing demand for accurate hearing tests requires thorough knowledge of proper testing. Masking is a complex procedure to understand and execute because of a lot of variables which operate simultaneously and many of them under very tenous control.(Ventry, 1971).

In the present century, ever since Wegel & Lane (1924) first reported of changes in thresholds in test ear when a masking noise was simultaneously delivered to the nontest ear at low intensity levels (Quoted by Dirks & Malmquist, 1964), there has been a lot of research going on, discussing both theoretical and clinical aspects of masking. Theoretical aspects have been stressed by such authors as Hawkins & Stevens, Bilger & Hirsh, Dirks & Malmquiat, Chaiklin, etc; the clinical aspects have been discussed by Hood, Studebaker, Beadle, Martin & Staab, etc (Goldatein, 1979). Inspite of this increased emphasis, as Studebaker (1967) quotes "in masking most of it is confusing, much of it is incomplete and a large portion of it is inaccurate and misleading."

Masking is a dangerous tool in the hands of ignorant. Hence, instead of giving mere procedure a theoretical orientation is deemed to be a must. Following questions need to be answered in connection with masking:-

- What is masking?
- What is the purpose of masking?
- What are the types of masking?
- What are the types of masking noises?
- When to mask?
- How much to mask?
- How to mask?

Each one Will be answered in brief.

What is Masking?

Masking has been defined as

(1) the process by which threshold of audibility of one sound is raised by the presence of another sound (masking sound)

(2) the amount by which the threshold of audibility of sound is raised by the presence of another sound (Masking sound). The unit customarily used is dB. (American Standards Associations,1960)

Masking is best defined operationally as an elevation in the threshold of one signal by the introduction of another signal. The first signal is called maskee or test signal and the second signal, masker.

<u>What is the purpose of Masking?</u>

Precise specification of subjects auditory thresholds and suprathreshold functions (discrimination, recruitment, adaptation etc) is a complicated process when there is a large difference in sensitivity between ears. In such cases, unknown amount of energy may be impressed simultaneously upon the opposite ear and so erroneous results are obtained. It becomes important to isolate the ears acoustically, this is accomplished by introducing a masking sound to the nontest ear to temporarily suppress the threshold sensitivity of that ear. Complete desensiiization of untested ear is rarely necessary, a sufficient downward shift Mill be sufficient to not to contribute to the responses of the test ear. (Winchester, 1968).

Need for masking is therefore because of two factors:

(1) Cross hearing: In unilateral hearing loss or asymmetrical loss cases, uhen the tone is presented to poorer ear, it may be transferred to and heard in the better ear, well before reaching the threshold of the poorer ear. This leaking of the test tone from test tone around the head is called the cross overof tone or head shadow. This cross over of signal results in shadow curve response. Here masking

helps to isolate the nontestear from test ear by keeping the test ear 'busy' with masking signal to obtain valid results of nontest ear.

(2) Second factor is that the be signals tend to stimulate both the cochleas simultaneously, nearly equally, even at low levels. So, in be testing it is often difficult to know as to which ear is actually being stimulated.

What are the types of Masking?

Contralateral masking: When the masking noise is presented to the opposite ear to that of the test ear, contralateral masking is resulted.

Ipsilateral masking: Ipsilateral masking is done by introducing the noise to the test ear itself.

Cross masking or transcranial masking: It is a contra-lateral phenomenon and occurs when masking applied to one ear leaks around the head (trans-cranium) i.e., crosses the head and masks the other ear. This is observed because two ears are not acoustically isolate completely.

Central Masking: Two ears are not neurologically separate. They share a common nervous path to brain. So, masking in nontest ear also affects the test ear threshold. When a low level of masker of insufficient intensity to cross the skull to opposite ear is introduced into one ear, it tends to produce a small threshold shift in the other ear. This shift is called 'central masking'.

Perstimulatory masking: Here the tone is presented at various times during ontime of masker and the course of masking as a function of time is determined.

These three methods i.e., forward, backward and per-stimulatory are nonsimultaneous methods.

Masking can be also direct or remote masking.

Remote masking: Remote masking is observed if threshold shift occurs in the same ear produced by a masker of different frequency.

What are the types of masking noises?

A variety of signals have been used as maskers.

(1) Pure tones, (2) Marble tones, (3) Compressed air, (4) Noise: complex noise, broad band noise, narrou band noise, speech noise, pink noise.(Shukla 1980)

For puretone testing, narrou band noise is the most recommended noise.

When to Mask?

The opposite ear must be masked whenever there is an indication of cross hearing is indicated. The danger of cross hearing is determined by (1) presentation level of test signal

(2) interaural attenuation, (3) threshold sensitivity of nontest ear. These two vary for air conduction and bone conduction testing.

Air Conduction Testing:

Even when tone is presented by air conduction, it Mill cross the skull by bone conduction whenever its intensity at test ear is about 50 dB greater than bone conduction threshold of nontest ear, regardless of air conduction threshold in the nontest ear. Thus Mhen to mask depends upon the sensory-neural sensitivity in the nontest ear. (Sanders, 1978).

Second factor to be considered is the Interaural attenuation for air conducted stimuli. Interaural attenuation is the attenuation in the intensity of an auditory stimuli in crossing from the ear of presentation to the opposite ear. Here it becomes necessary to mask whenever air conduction presentation level at the test ear exceeds bone conduction threshold of opposite ear by more than the smallest expected interaural attenuation. (Studebaker, 1967).

So the rule is "In air conduction testing, nontest ear must be masked whenever the signal presented to the test ear exceeds bone conduction sensitivity in the nontest ear by more than 40dB.

Bone conduction testing:

Clinical evidence and research finding suggests that interaural attenuation for a signal presented by bone conduction is negligible and so it is necessary to always mask while testing bone conduction.

Menzel (1969) has listed 3 conditions uhen masking is not necessary but in all other conditions:

(1) when unmasked threshold is approximately equal to the air conduction threshold of that ear.

(2) when unmasked thresholds of that ear are better than those of opposite ear.

(3) when sound is not heard at the upper limit of audiometer.

Studebaker (1964) has given the rule for masking in bone conduction testing as "In bone conduction audiometry, nontest ear should be masked, whenever test ear exhibits an air bone gap".

In 1980, Vyasamurthy has given some rules for when to mask:

(1) If an unmasked audiogram shows bilateral moderate/moderately severe/severe hearing loss with normal BC thresholds or significant loss through impedance audiometry, the true BC thresholds of SM loss ear can be determined by masking the nontest ear provided the air bone gap of nontest ear does not exceed 30dB.

(2) If an unmasked audiogram shows bilateral moderately severe/ severe hearing loss with normal BC thresholds or significant air bone gap uith affected BE thresholds and if one of the ears is found to be sensorineural loss through impedance audiometry, the true AC thresholds of SN loss ear can be determined by masking nontest ear provided the true AC threshold of test ear does not exceed air bone gap of nontest ear.

(3) If an unmasked audiogram shouts bilateral mixed loss, the true AC thresholds of ears can be determined by masking nontest ear provided the sum of air bone gap of two ears do not exceed 80dB.

How much to mask?

Wore 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. (Henzel, 1968).

Before going into the discussion about the amount of masking some of the terms need to be explained.

Minimum masking level:

This is the level of masking noise just sufficient to mask the test signal in the masked ear. It is used for screening purpose, a level of masking equal to threshold of nontest ear it used.

Maximum masking level:

Masking intensity must not be so great as to shift the threshold in the test ear by cross over from the masked ear. This level, the maximum masking level is defined as the intensity just insufficient to mask the test signal in the test ear. (Studebaker, 1967).

Maximum masking can be presented before the noise becomes so intense that a different form of test contamination / over-masking takes place (Martin, 1980).

Maximum masking is determined by three factors:

(1) BC threshold of the test ear

(2) Skull attenuation

(3) Discomfort threshold of patient for the proposed masking level (Liden, 1971).

The calculation of levels of minimum and maximum masking levels are essential to avoid under and over masking. Under masking results if the level of noise is below the minimum masking level so as to not to mask the test tone in the nontest ear. Over masking is observed if the noise level exceeds maximum permissible level and so masks the test tone in the test ear itself, contaminating the results.

Any masking level falling above that uhich is just sufficient to mask the tone reaching masked ear (minimum necessary masking) and belou the level uhich is just sufficient to shift the threshold of tested ear (maximum permissible masking) is the correct noise level required. (Zwislocki, 1951) For normal hearing subjects, the range between the two ia equal to interaural attenuation. But a hearing loss in one or both ears alters noise level requirements by changing the relationship between the thresholds of two ears.

So, several investigators have tried formulations and procedures to facilitate the selection of appropriate noise level for effective masking so that threshold might be obtained without tracking entire function. The underlying assumptions are:

(1) only one plateau exists;

(2) that this plateau represents true threshold;

(3) that knowing the amount of masking needed to mask normal ears we can extrapolate to patients who have hearing deficit;

(4) that the individual differences in response characteristics motivation and in central noise effects are nonexistent, negligible or uncontrollable (Venler, 1965). Liden et al 1959 have given the masking formula as follows:

Minimum effective masking for air conduction;

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

therein A. = AC threshold of the test ear

$A_m - B_m$ = air bone gap of masked ear

IA = interaural attenuation.

Minimum effective masking for bone conduction:

$= B_t + (A_m - B_m)$

wherein

B_t = 3C threshold of the test ear

$A_m - B_m$ = air bone gap of the masked ear.

Maximum masking = $B_t + 40$
provided level does not exceed
patient discomfort level

wherein

B_t = BC threshold of the test ear.

Martin (1967) has given formulae for calculation of levels of masking as:

Minimum masking for air conduction

$= A_{NTE}$ + M.F. + S.F.

wherein

A_{NTE} = AC threshold of the nontest ear

MF = Masking factor

SF = Safety factor

Minimum masking for bone conduction

" A_{NTE} + MF + SF + OE/AB gap.

therein

A_{NIE} = AC threshold of the nontest ear

MF = Masking factor

SF = Safety factor

DE = Occlusion effect

AB gap = Air bone gap of the nontest ear

How to mask?

- obtain thresholds of both the ears without masking.
- decide the need for masking.
- obtain the amount of Masking at each frequency
- start presenting the masking noise in the nontest ears at the predetermined level (Minimum).
- obtain the cure tone thresholds in the test ear.
- increase the noise by 5 dB and check for the threshold.
- repeat the procedure of increasing noise in nontest ear till the point wherein subsequent 10dB increase in noise does not result in threshold change. At this point the plateau has been reached and the threshold is the real threshold of the test ear.
- record the threshold and the masking level used (Goldstein) "Masking threshold should never be believed as true threshold unless same masked threshold is obtained for at least two different levels of noise". (Menzel,1968).

Mechanism of Masking:

There are two possible conceptions of mechanism of masking (Moore, 1982).

(1) The most common among psychologists is that masking involves swamping of activity evoked by the signal. If masker produces significant amount of activity in channels (auditory filters/critical bands) which would normally respond to the

signal, then the activity added by signal is undetectable. For eg:- consider the case of tone with unite band noise. When tone is at its masked threshold, the level of tone is about 4dB less than the level of noise in critical band around the tone. This is the average discrepancy between critical bands and critical ratios; 4 dB corresponds to power ratio of 2.5:1. The combined effect of excitation produced by tone and noise will be about 1.5dB higher than that produced by noise alone. Thus one might say that 1.5 dB increment is necessary for detection of tone. If tone is much lower in level than noise passing through critical band, then it Mill produce a negligible increment in excitation. So, the excitation produced by tone Mill be swamped by that produced by masker.

(2) Another vieM common among neurophysiologists, is that masker supresses the activity which the signal Mould evoke if presented alone. This is explained by two tone suppression. The neural response to a tone at a characteristic frequency of neurone may be suppressed by tone which does not itself produce excitatory activity in the neurone.

At present there is not a clear May of distinguishing betMeen these two mechanisms. All that is known is that swamping mechanism is a linear process and the suppression, a nonlinear process.

Masking in pathological ears:

Most of the formulae for masking have been derived based on the experiments on normal ears with the presumption that the same amount of masking serves as the optimum level in pathological ears also with some exceptions.

Palva, Goodman & Hirsh (1953) in an extensive investigation concluded that their averaged masking data from several groups of hearing impaired and normal listners were virtually indistinguishable. Palva et al measured threshold in 1odBHL noise in 82 hearing loss cases (16 conductive loss, 36 mixed, 5 sensorineural without recruitment, 14 sensorineural with recruitment, 11 sensorineural without recruitment being tested). But the individual data from 6 of their 8 frequencies display a range of masked thresholds that is 20dB or greater with maximum range of 35 dB at 250 Hz, indicating a large individual difference. (Quoted by Tyler et al, 1982).

Simon subsequently reported averaged thresholds of 9 listners with recruitment displaying higher masked threshold than normal (quoted by Tyler, et al, 1982)

Harbert & Young examined the relation between abnormal threshold adaptation and broad band masking.. Their listners without abnormal adaptation showed normal masked threshold, whereas those with abnormal adaptation threshold showed elevated masked thresholds. (Quoted by Tyler, et al 1982).

According to Liden et al (1954) the effect of masking usually designated as the central masking effect can account for 15dB even in patients with inactive middle ear.

3erger & Bucy (1960), Jerger & Mailer (1962) reoorted data on two listners with confirmed retrocochlear pathology. 8oth displayed normal amounts of masking at test frequencies above 250HZ. Homever, one showed 10dB more masking at 125HZ & 250Hz; and the other about 10dB more masking at 250Hz.

Jerger, Tillman & Peterson (1960) studied masking effect of bands of random noise that located in low frequency (400-800 Hz) mid frequency (1200-2400 Hz) and high frequency (3200-6400Hz). Noise level for each of the bands was adjusted to produce effective masking levels of 10 and 30 dB within the band, for each subject. In addition to normal hearing group, 5 different categories of impaired ears Mere tested. They concluded that when a given noise is adjusted to equivalent effective levels for normal and the senaorineural ears, the impaired ear will show excessive masking in frequency regions both above and below the noise band.

Since the effective levels of noise were same for all subjects, the impaired ears were tested in masked intensity levels which were considerably higher than those of normal group. Jerger et al adjusted for this factor by comparing 30dS effective level data of their sensorineural group to normal data of Bilger & Hirsh for approximately equivalent intensity levels of masking noise. when the masked threshold for two groups. were plotted in dBSPL, sensorineural group again showed higher than normal threshold outside masking band. This Mas felt to substantiate the conclusion that ears Mith sensorineural loss show greater than normal spread of masking (Quoted by Martin & Pickett, 1970).

Rittmanic (1962) studied indirect masking in normal subjects, plugged normals and sensorineural cases. They were masked by 100dBSPL of random noise which Mere centered at 250, 500, 1000, 2000 & 4000HZ. He found that the masked thresholds for sensorineural group Mere at higher SPLs than normals. Rittmanic interpreted his data as indicating that in equal SPLs of narrow band noise, the ear with sensorineural loss exhibits greater spread of masking than does the normal ear. When amplified by a low frequency hearing aid, moderate levels of environmental sounds may be sufficiently intense to produce spread of masking. Since substantial amounts of speech information are found in mid frequencies, excessive masking in this region could further reduce discrimination that is already impaired. If persons Mith sensorineural loss do infact exhibit greater than normal spread of masking, recommondation of loM frequency aids may be inadvisable. (Quoted by Martin & Pickett, 1970).

But Martin & Pickett (1970) feel that neither the amount of masking threshold shift nor level of masked threshold are adequate for determining if a subject Mith sansorineural loss shows greater than normal or less than normal spread of masking. In the ears with restricted dynamic range, small amounts of threshold shift reoresent large amount of masking. Martin & ^ Pickett feel that if the soread of masking has to be determined, a measure must be used Mhich will take into account both the degree and configuration of loss in impaired ear. They tested the pure tone thresholds in quiet and in 3 levels of masking noise for one normal hearing group (6 subjects) and 5 groups of subjects (27 cases) Mith different degrees of hearing loss. Masker was a low pass noise cut off at 250 Hz. It Mas presented at overall levels of 77, 97 and 107 dBSPL. Pure tone thresholds Mere obtained at test frequency Mithin and above masking bands. A measure of noise rejection slope was used to describe upward spread of masking. They found (1) marked differences within sensorineural group and sensorineural group did not show characteristic change. (2) Amount of upward spread did not appear to be related to degree of loss. They observed equivalent amount of upward spread in normals and in those with mild moderate or severe loss of sensitivity. (3) Subjects with similar audiograms did demonstrate markedly different amount of upward spreading. (4) These differences Mere seen even in normal hearing subjects. Their data suggest that there may be cases Mherein use of a hearing aid with extended low frequency response would result in poorer aided discrimination due to spread of masking, than would be attained with an aid having conventional low frequency cut off. So, Martin & Pickett suggest that before low frequency emphasis hearing aids are recommended, additional information is needed concerning upward spread of masking.

Laucius & Young (1972) trade threshol and amplitude measurements of fixed Bekesy tracings in the presence of contralateral white noise in 6 normal and 24 with unilateral sensorineural loss subjects. In normals, the threshold steadily increased linearly as level of masking rose above transcranial attenuation, while tracing amplitude remained unchanged. In hypacusics, when normal ear was masked and thresholds were traced from defective ear, steady tone yielded tracing amplitude change and greater threshold shift. When the pathological ear than normal ear was masked, 7 of the 24 showed threshold shift and reduced amplitude when intensity level of noise was too low for cross hearing. Changes were insignificant with pulse tones. Laucius & Young quote ward's (1963) suggestion of central masking to explain this. But still the question remains as to if the shift in the threshold and amplitude of the continuous tone is due to central masking, cross hearing or pathologic condition.

Smits & Duiftius (1982) experimented on 3 listners with sensorineural loss of moderate - moderately severe degree starting at frequencies higher than 1 KHz. In the first experiment, fm = 1 KHz and L_m = 50 dB SPL higher than normal masked threshold were obtained for listners whose hearing was impaired in frequency region of clear loss as well as in the region of normal loss. In the second experiment it was shown that for hearing impaired listners, the elevation of masked threshold in dBs in this frequency region of near normal absolute threshold was equal to elevation of absolute threshold in dBs. The partial masking with fm = 975-1025 Hz and L_m = 76 dBSPL showed similar function for normals and pathologic ears, but with functions for hearing impaired at higher levels of partially masking orobe tone. Thus the higher masked threshold of hearing impaired can result in dramatic reduction of dynamic range of hearing under masking in the frequency region of hearing loss, even if loss is small. So, the masker need not be very loud to provoke an abnormal upward spread of masking for hearing impaired listners.

Tyler Fernandes & Young (1982) tried to obtain masked pulse tones threshold for 500, 1000, 2000 and 4000 Hz in the presence of different levels of broad band noise 0, 20, 40, 60 dB/Hz. Several of the 16 cochlear patients displayed masked threshold that were considerably higher than those from 10 normal ears. At 60 dB/Hz correlation coefficient between threshold in noise and threshold in quiet were r = 0.36, 0.44, 0.63, 0.64 for respective frequencies. The growth of masking as the masker level is increased Mas linear function for normals, but was disproportionate and nonlinear for some cases. So, threshold in noise cannot be predicted from the threshold in quiet. Masked thresholds are related to other measures of frequency resolution and to speech intelligibility in noise, but it is argued that Dsychoacoustic tuning curves provide more direct measurement of auditory filter characteristics.

Flilburn (1978) has given the mechanism of masking in a pathological ears.

(1) Sensorineural loss: Unilateral hearing loss presents difficulty of determining the level of residual hearing by bone conduction in poorer hearing ear as shown by air conduction testing.

Hearing for pure tones is within normal limits for the left ear. Unmasked thresholds of right ear indicate a loss for all frequencies for air conduction but not for bone conduction. The unmasked bone conduction of right ear indicate better hearing than for the left. The masked bone conduction indicate a complete loss of responses.

The table shows the masking levels and the responses obtained, This is the plateau method. Initial response at 1 KHz was 40 dB for 55 dB noise. The test tone was heard at 40 dB when masking stimulus was increased to 60 dB, and the test tone was heard again at 50 dB, with the masking stimulus increased to 65 dB. The relationship here is that a 10 dB masking stimulus intensity directed to nontest ear masked an increase of 5 dB in test tone intensity.

So, the nature of masked audiogram itsalf shows that the loss is not conductive in nature.

TABLE 1

NBWN Masking (dBHL)	Frequency (Hz) 250	500	1000	2000	4000
0	0	0	0	10	20
55	20	35	40	50	NR
60	20	40	40	60	
65	25	45	50	65	
70	25	50	55	75	
75	35	50	55	NR	
80	40	50	60		
85	NR	60	6Q		
90		MB	65		
95			MR		
100					

Bone conduction thresholds: Sensorineural loss ear.

(2) Conductive loss: Bilateral conductive loss is Duzzling to determine extent and type of loss of each ear. The audiogram shouts n*ild - moderate conductive loss. The unmasked bone conduction is at 10 dB for each ear. But the threshold shifted in each ear htith masking.

The responses shOM that for right ear responses shifted from 10 dB to 20 dB over the range of 0 to 100 dB and 10 dB to 30 dB for the left ear. Right ear 20 dB response could be because of over masking.

TABLE II

NBWN Masking (dBHL)	Frequency (Hz) 250	500	1000	2000	4000
0	-5	5	10	5	0
55	-5	5	10	5	10
60	-5	5	10	5	10
65	-5	5	10	5	10
70	-5	5	10	5	10
75	-5	5	10	5	10
80	0	5	10	5	10
85	0	5	10	5	10
90	0	5	10	5	15
95	0	5	10	5	20
100	0	5	20	5	20

Bone conduction thresholds: Conductive loss. (right ear)

TABLE III

NBWN Masking (dBHL)	Frequency (Hz) 250	500	1000	2000	4000
0	0	5	10	10	10
55	0	5	15	10	10
60	0	5	15	10	10
65	0	5	15	10	10
70	0	5	15	10	10
75	0	5	15	10	10
80	0	5	30	10	10
85	0	5	30	10	10
90	0	5	30	10	10
95	0	5	30	10	10
100	0	10	30	25	15

Bone conduction thresholds: Conductive loss in left ear.

So, the extent of a threshold shift produced by a masking stimulus to the ooDOsite ear seems to be directly related to the type of hearing loss. Eg:- increase in the masking level from 0 dB to 55 dB resulted in a threshold shift of 40 dB in sensorineural loss and nil in conductive loss.

Milburn also found a similar relation existing between type of loss and the manner in which threshold shift represents itself as the masking stimulus is increased. The shift for sensorineural loss Mas rather dramatic at least at 55 dB masking level, compared to conductive loss. So, it seems likely that masking with a sensorineural loss will result in a threshold shift with the application of minimal amount of masking, but that the use of same amount of masking will produce no shift in a case of conductive loss.

CHAPTER - III

METHODOLOGY

The present study was aimed to see whether the maximum effective masking levels obtained in hearing loss subjects would agree with the calculated (predicted) maximum effective masking levels.

SUBJECTS:

Three groups of subjects were studied:

(1) Normal hearing grouo

(2) Conductive hearing loss group

(3) Sensorineural hearing loss group.

15 normal hearing subjects were selected for the first group (age range 18 years to 22 years, Wean age 19½ years). All of them had air conduction thresholds less than or equal to 25 dB HL (ANSI, 1969) in the frequencies from 250 Hz to 4000 Hz in both the ears and had air bone gap less than 10 dB HL. None of them had any history of previous auditory disorders.

12 conductive hearing loss cases were candidates for the second group, (age range 17 years to 55 years. Mean age: 35 years). All of them had either unilateral or bilateral conductive hearing loss of mild to moderate degree. The conductive loss was confirmed by impedance audiometry and/or ENT examinations.

The last group consisted of 5 unilateral or bilateral sensorineural hearing loss cases (age range: 25 years to 75 years, Mean Age: 47 years) of mild degree. Sensorineural hearing loss was confirmed by impedance audiometry.

INSTRUMENTATION:

The instrument used for the study was a two channel audiometer. (Seltone 200c) and an impedance bridge (2073). The audiometer was connected to TDH 39 ear phones fitted with MX 41/AR ear cushions. The audiometer was objectively calibrated regularly (ANSI 1969). In addition, biological calibration was done every time before collecting the data.

TEST ENVIRONMENT:

The data Mere collected in a sound treated two-room condition.

TEST PROCEDURE:

Firstly, the air conduction and bone conduction thresholds for Dulsed tones for each ear were obtained for frequencies from 250 Hz to 4000 Hz, using a modified Hughson westlake procedure (Carhart & 3erger, 1959). The impedance audiometry was done to get the static compliance, tympanogram and reflexes for each ear. The results of impedance audiometry were used for the selection of subjects.

EAR SELECTION:

while testing the normal subjects, the right ear was tested by introducing noise in the left ear. while testing the unilateral hearing loss cases, the pathological ear was selected as the test ear and the normal ear was the nontest ear. i.e., the noise was introduced to the nontest ear (non-pathological ear) and the tone was presented to the test ear (pathological ear). In bilateral hearing loss cases, the ear with flat loss was selected as the test ear and the other ear was used as the nontest ear.

OBTAINING MAXIMUM EFFECTIVE MASKING LEVELS:

All the subjects Mere instructed in the following manner:

"Now you are again going to hear pulsed tones in your right ear (or left ear). At the same time you will hear noise in your other ear, the intensity of which keeps varying. Ignore the noise and concentrate on the pulsed tones. Keep your finger up as long as you hear the pulsed tone and drop your finger as soon as the pulsed tone becomes inaudible. Now listen carefully."

The instructions were repeated whenever there was an indication of the subject not having understood the instructions.

To obtain the maximum effective masking levels, first, the pulsed tones Mere given at threshold in the test ear. Then the narroM band noise Mas introduced to the opposite ear at 50 dB EL.

Once the noise was introduced, the subject's response for pulsed tones was noted. The masking noise was increased in 5 dB steps in the nontest ear until there was no response for pulsed tones i.e., until the noise masked the pulsed tones at threshold. The test was terminated at this point or when the maximum audiometric level was reached.

To check the reliability of the responses, sometimes the test tone Mas turned off well below the level of masking or suddenly the noise was turned off in cases of 'no response' to observe the responses of the subject.

The procedure was repeated at 10 dBSL. This was included as the reliability of the responses at threshold appeared to be poor.

Using the above procedure, maximum effective masking levels for pulsed tones at different frequencies at threshold and 10 dBSL were determined.

The level at which the subject stopped responding for pulsed tones was taken as the level of maximum masking and the dial reading of masking was noted down. The maximum effective masking levels required to mask the pulsed tones at 10 dBSL were used for statistical analysis.

C H A P T E R - IV

RESULTS AND DISCUSSION

The treasure of central tendency (Dean) and the dispersion treasures (Standard Deviation) of maximum effective masking levels obtained in normal and pathological ears were computed. The raw scores obtained are shown in the tables at the end of this section.

(1) The Normal hearing group:

The maximum effective masking levels obtained in normal subjects showed a maximum variation of 20 dB. The means and standard deviations are given in Table XI. At 250 Hz, for 4 normal hearing subjects, the maximum effective masking level could not be obtained because of the limitation of the maximum out put level of noise of the audiometer, (the maximum effective masking level was 70 dBEL at 250 Hz whereas it was 90 dBEL at all other tested frequencies).

(2) The sensorineural hearing loss group:

Only 5 available subjects could be tested. Though the precaution was taken to select the sensorineural hearing loss subjects with loss less than 40 dB, in most of the cases, the maximum effective masking levels could not be obtained, at any frequency. Only in 3 subjects, the maximum effective masking level could be recorded at only one frequency. Here again, the maximum noise out put level of the audiometer was the limitation. In none of the subjects, response at 10 dBSL could be obtained at any frequency.

(3) The conductive hearing loss group:

The obtained maximum effective masking level and the predicted maximum effective masking levels Mere compared.

a. The obtained maximum effective masking level:

The means and the standard deviations for each frequency are shoMn in the Table XI. The mean maximum effective masking level was lowest at 250 Hz and highest at 4000 Hz. The dispersion measure showed not much of a variation at any frequency, though the sample size was limited to 12 subjects. There was not any characteristic response observed for any of the type of hearing loss (i.e., etiology) or for different degree of hearing loss. Even in this group 50% of the subjects tested did not show any response at 250 Hz which could be attributed to the audiometric limitation.

b. <u>The predicted maximum effective tasking levels:</u>

The maximum effective masking levels were predicted from the following:

Subject's threshold for air conducted pulsed tones, air-bone gap of the test ear and the maximum effective masking level obtained in normals.

The formula used was:

Predicted maximum effective masking level for conductive loss ear = AC_+ + Mean Max EML_N - (A_m -B_m)

wherein

AC_t = air conduction threshold of the subject.

Mean Max EML_N = Mean maximum effective masking level of normal subjects.

A_m -B_m = air-bone gap of the test ear (pathologic ear).

The means and standard deviations of the predicted maximum masking levels at each frequency are shown in the Table XI. The predicted levels were found to be consistently greater than the obtained levels. However the variation was not much. Again the mean predicted maximum effective masking levels were lowest at 250 Hz and highest at 4000 Hz.

Both the predicted and obtained maximum effective masking levels were higher than the mean maximum effective masking levels of normal hearing subjects. The predicted and obtained values of maximum effective masking Mere compared to find if the difference between them was statistically significant.

At 250 Hz, the difference between mean predicted and obtained maximum effective masking levels Mas 16.21 dB which Mas statistically significant at both 0.05 and 0.01 levels. The score at 0.05 and 0.01 levels are 2.57 and 4.03 respectively, both the values are less than the calculated score of 6.56.

The difference at 500 Hz between mean predicted and obtained maximum effective masking levels was 4.58 dB. Though this value is small, the difference was statistically significant at 0.05 level of significance. The t score at 0.05 level is 2.23 and the calculated t value of 2.95 is higher than this value.

At 1 KHz, a difference of 12.92 dB between predicted and obtained maximum effective masking levels (means) was observed. This difference was statistically significant at both 0.05 and 0.01 levels of significance. The calculated t value of 5.06 is much greater than the table values of 2.20 and 3.11 at 0.05 and 0.01 levels of significance.

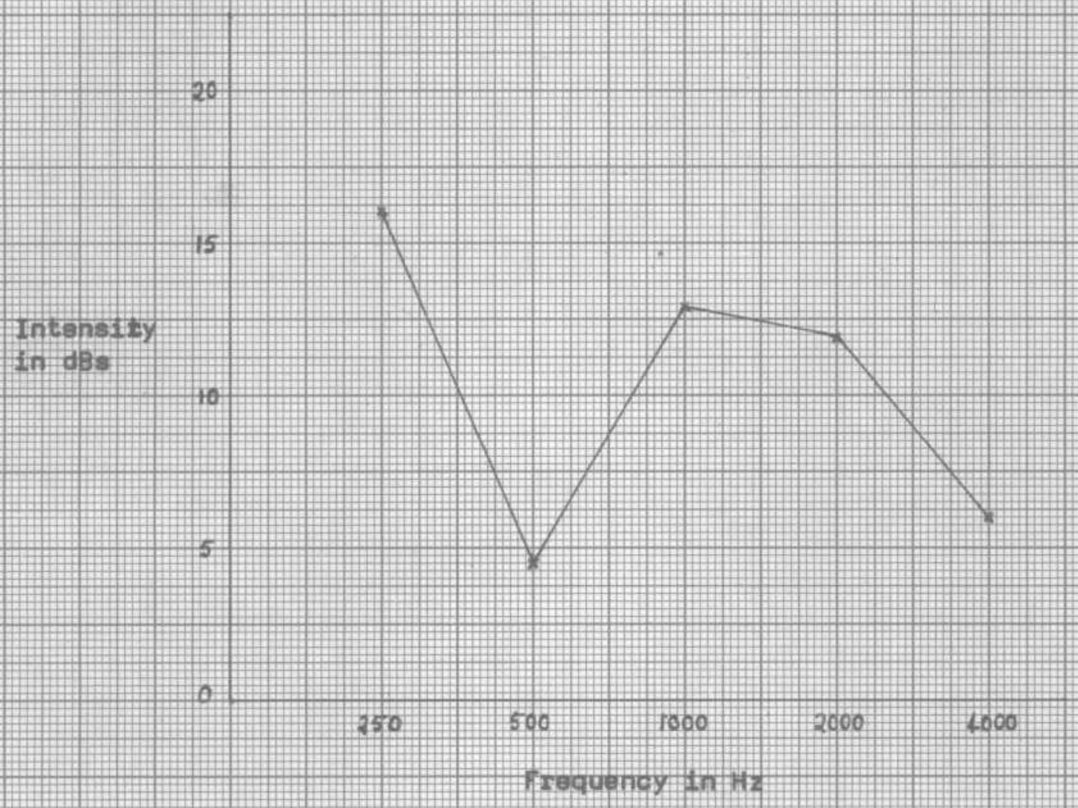
A difference of 11.88 dB between the mean predicted and mean obtained maximum effective masking levels was observed at 2 KHz. Again, this was statistically significant at 0.05 and 0.01 levels of significance i.e., the value of 3.14 being higher than 2.20 and 3.11 table values of 0.05 and 0.01 levels of significance.

The difference observed between predicted and obtained maximum effective masking levels (means) was 6.06 dB at 4 KHz. This difference was not statistically significant at both 0.05 and 0.01 levels of significance. The value calculated (1.41) was lower than the table values of 0.05 and 0.01 levels of significance.

The graph shows the difference between mean predicted and mean obtained maximum effective masking levels of conductive hearing loss group. The difference ranges from 4.58 dB (500 Hz) to 16.21 dB (250 Hz). But, even for threshold values, a difference of ± 5 dB is allowed.

Hence, the difference of 16 dB cannot be considered as significant for oractical purposes in clinical testing. This shows that there is a good agreement between the predicted and the obtained maximum effective masking levels.

The results of the present study reveal that the formula of maximum effective masking is valid for clinical population. Hence, the audiologists can rely on the formula for clinical masking of the non-test ear.



GRAPH SHOWING THE DIFFERENCE BETWEEN MEAN OBTAINED AND MEAN PREDICTED MAXIMUM EFFECTIVE MASKING LEVELS IN CONDUCTIVE LOSS GROUP.

TABLE - IV

Showing the ac thresholds of the test ear in normal hearing group

Subject	Intensity in dBs	Frequency in Hz AC threshold of TE 250	500	1000	2000	4000
(1)		10	15	5	0	5
(2)		20	20	5	0	0
(3)		20	20	0	0	10
(4)		10	15	5	0	0
(5)		10	15	10	5	10
(6)		10	10	10	10	5
(7)		10	10	0	5	0
(8)		15	20	0	5	5
(9)		10	10	0	0	0
(10)		20	20	10	0	5
(11)		10	15	0	10	5
(12)		10	15	3	5	5
(13)		10	15	15	5	10
(14)		5	10	10	5	5
(15)		5	15	5	5	10

TABLE - V

The obtained Maximum effective masking levels in normals

Subjects	Frequency in Hz				
	Intensity in dBs 250	500	1000	2000	4000
(1)	NR	65	65	65	80
(2)	70	65	70	65	70
(3)	70	80	75	75	75
(4)	70	65	70	65	70
(6)	65	65	70	70	75
(6)	NR	65	80	70	80
(7)	70	70	70	70	80
(8)	65	65	70	65	65
(9)	70	75	70	70	65
(10)	NR	70	75	70	75
(11)	55	60	75	70	85
(12)	NR	85	85	80	85
(13)	70	70	65	60	70
(14)	50	65	75	60	70
(15)	55	60	60	60	75

TABLE - VI

AC thresholds of the test ear in conductive hearing loss group

Subjects	Frequency in Hz				
	Intensity 250 in dBs	500	1000	2000	4000
(1)	40	40	45	40	65
(2)	50	50	30	20	50
(3)	25	45	50	55	90
(4)	40	40	45	45	45
(5)	40	30	35	40	40
(6)	75	60	55	50	60
(7)	55	70	65	60	55
(8)	40	25	25	35	45
(9)	60	60	55	70	65
(10)	35	25	20	35	30
(11)	50	50	45	40	40
(12)	50	50	45	35	40

TABLE - VII

Obtained maximum masking levels in conductive hearing loss group

Subjects	Intensity in dBs	Frequency in Hz 250	500	1000	2000	4000
(1)		NR	80	80	75	90
(2)		NR	80	65	55	NR
(3)		70	90	85	90	90
(4)		NR	80	75	70	90
(5)		65	80	75	70	70
(6)		65	70	65	65	80
(?)		55	70	75	85	85
(8)		NR	80	80	75	80
(9)		65	80	60	75	85
		NR	70	60	60	85
(11)		NR	80	85	80	85
(12)		60	75	75	55	75

TABLE - VIII

a-b gap of the teat ear in the conductive hearing loss group

Subjects	Frequency in Hz				
	Intensity in dBs 250	500	1000	2000	4000
(1)	15	10	20	15	45
(2)	50	35	20	5	20
(3)	10	30	40	40	65
(4)	30	30	35	45	45
(5)	20	20	20	20	15
(6)	50	60	40	30	55
(7)	45	60	55	50	40
(8)	35	15	15	20	40
(9)	50	50	45	60	55
(10)	15	10	5	15	10
(11)	20	25	15	15	20
(12)	40	30	30	25	40

TABLE - IX

AC thresholds of the test ear in SN loss group

Subjects	Intensity in dBs	Frequency in Hz				
		250	500	1K	2K	4K
1		25	30	35	40	35
2		50	55	55	55	60
3		20	25	30	30	35
4		20	30	40	35	35
5		30	35	40	35	40

Maximum obtained masking levels in SN loss group

Subjects	Intensity in dBs	Frequency in Hz				
		250	500	1K	2K	4K
1		NR	NR	NR	NR	NR
2		NR	NR	NR	NR	NR
3		NR	NR	NR	NR	NR
4		NR	NR	NR	NR	NR
5		NR	NR	NR	NR	NR

TABLE - XI

Showing the Means and standard deviations of Maximum Masking Levels of Normal & Conductive Loss groups

Frequency (Hz)		Normal Hearing Group	Conductive loss group	
			Predicted Max. Masking	Obtained Max. Masking
250	Mean	64.54	79.54	63.33
	S.D.	7.26	8.66	4.76
500	Mean	68.33	82.50	77.92
	S.D.	6.78	7.56	5.53
1000	Mean	71.66	86.25	73.33
	S.D.	6.04	6.18	8.53
2000	Mean	67.66	83.08	71.25
	S.D.	5.52	6.87	10.63
4000	Mean	74.66	89.24	83.18
	S.D.	6.26	9.92	6.16

TABLE - XII

The combined S.Ds, S.Es, and   Scores of the Obtained & Predicted Maximum Effective Masking Levels of Conductive Loss Group

	S.D.	S.E.	t
250	6.06	2.47	6.56
500	13.24	3.82	2.95
1000	8.82	2.55	5.06
2000	12.12	3.50	3.14
4000	10.96	3.30	1.41

C H A P T E R-V

SUMMARY AND CONCLUSIONS

The present study was aimed at finding out the maximum effective masking levels in normal and pathological (conductive and sensorineural) ears.

Three groups of subjects were tested. First group had 15 normal hearing (ANSI, 1969 criteria) subjects with no history of any auditory disorder. The second group had 5 mild sensorineural cases. The sensorineural hearing loss was confirmed by the presence of middle ear reflexes. The third group had 12 conductive hearing loss cases; the pathology was confirmed by impedance audiometry and/or ENT examinations.

The testing was done in a sound proof room, with two room situation, using a two channel (Beltone 200c) audiometer. For normal hearing group, right ear was the test ear, and for clinical groups, the ear with flat loss was the test ear. The maximum effective masking levels were obtained for each subject at test frequencies viz., 250, 500, 1000, 2000 and 4000 Hzs both at threshold and at 10 dBSL (pulsed tones were used) using NB noise in the nontest ear.

The levels obtained were statistically analysed to determine the means and standard deviations. In addition, significance of difference between means was also computed. The results showed that;

(1) The mean maximum effective masking levels of normals were lower than the mean maximum effective masking levels (oredicted and obtained) of conductive hearing loss group.

(2) Maximum effective masking levels could not be determined in sensorineural hearing loss group (pulsed tone was presented to the sensorineural loss ear and NB noise was presented to the normal ear or opposite ear) as the maximum effective masking levels exceeded the maximum output limit of the audiometer. The maximum output for noise was 90 dBEL for all the tested frequencies except at 250 Hz wherein it was 70 dBEL.

(3) The predicted and obtained mean maximum effective masking levels were lowest at 250 Hz and highest at 4000 Hz for the conductive loss ears (test ears).

(4) The difference between predicted and obtained mean maximum effective masking levels (for the conductive loss ears) was statistically significant at the test frequencies 250, 500, 1000 and 2000 Hz but not significant at 4000 Hz.

(5) The difference between predicted and obtained mean maximum effective masking levels for conductive loss ears ranged from 4.58 dB (500 Hz) to 16.21 dB (250 Hz). Since the maximum difference between the predicted and the obtained mean maximum effective masking levels is just 16 dB, it can be considered that

the difference observed is insignificant for practical purposes (a difference of ± 5 d8 in absolute thresholds is not considered as significant difference in hearing testing). The present study reveals that there is good agreement between predicted maximum effective masking levels and the obtained maximum effective masking levels.

IMPLICATIONS:

The finding that the predicted maximum effective masking levels are nearly equal to the obtained maximum effective masking levels, establishes the validity of the formulae used for calculating maximum effective masking. The present study has resolved doubts regarding the validity of the formula used for calculating maximum effective masking levels. The audiologists can rely on the formula to decide over masking.

Additionally, the data of the present study can be used to find out whether the hearing loss of the subject is conductive or sensorineural hearing loss. Eg: if a subject of mild or moderate hearing loss continues to hear the tones presented at threshold levels to the test ear (pathological ear) when maximum effective masking narrow band noise (90 dBEL) is presented to the nontest ear, the hearing loss of the test ear can be considered as sensorineural hearing loss. The reason is that if the test ear has conductive hearing loss, the subject is not expected to hear the AC tones at threshold level when 90 dBEL noise is presented to the nontest ear. If the 90 dBEL noise in non-test ear fails to mask, AC tone at threshold level in test ear - it indicates that the BC threshold of the test ear is likely to be greater than or equal to 40 dBHL. (because 90-50 (I.A.) = 40). However, the observation that in 4 normal subjects, AC tones presented to the test ear (at threshold levels) ware not masked when 70 dBEL noise was presented to the nontest ear, undermines the previous generalization. Notwithstanding the type of response of the four normal hearing subjects, the previous generalization can be used with results of battery of tests.

A very important and useful implication of the present study can be explained here. Consider a case of unilateral microtia with atresia. If the case has moderate hearing loss in the ear with normal pinna and external auditory meatus, it will be difficult to find whether the hearing loss is conductive or mixed or sensorineural, as the opposite ear cannot be masked. Using the previously mentioned generalization, it may be possible to know whether the ear with normal pinna and normal external auditory meatus has conductive hearing loss or not. The procedure is simple - present 500 or 1000 Hz tone to the ear with normal pinna and normal external auditory meatus through the ear phone, at previously determined threshold level. Introduce narrow band noise at 90 dBEL through ear phone placed on the microtia and atresia ear. Ask the subject whether he hears the AC tone presented to the ear with normal pinna. If the subject fails to hear the tone, conductive hearing loss in the ear with normal pinna and normal ear canal, can be suspected.

The above example points out that the procedure of finding whether the subject responds to AC tone in the test ear at threshold level in the presence of 90 dBEL noise (narrow band) in the nontest ear, can be made use of clinically as a test to differentiate conductive and sensorineural hearing loss in difficult cases.

RECOMMENDATIONS:

(1) A large number of normal hearing subjects should be tested to find out - in how many normal hearing subjects, 90 dBEL noise (narrow band) in the nontest ear fails to mask the AC tones presented to the test ear at threshold levels.

(2) A large number of conductive hearing loss subjects should be tested to find out - in how many conductive hearing loss subjects, 90 dBEL noise (narrow band) presented to nontest ear fails to mask the AC tones presented to the test ear at threshold levels.

(3) A large number of mild sensorineural hearing loss cases should be tested to find out - in how many sensorineural hearing loss cases, 90 dBEL noise (narrow band) presented to the nontest ear masks the AC tones presented to the test ear (sensorineural loss ear) at threshold levels.

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