EFFECT OF CONTINUOUS AUDITORY STIMULATION ON AVERAGED REFLEX THRESHOLD

Register No. 8508

An independent project SuBmitted as part fulfilment for

first year M.Sc. (Speech and Hearinq)

to the University of Mysore.

All India Institute of Speech & Hearing
MYSORE - 570 006.

MAY—1986

IN LOVING MEMORY OF

MY"DODO"

CERTIFICATE

This is to certify that the Independent Project entitled "Effect of Continuous Auditory Stimulation on Averaged Reflex Threshold" is the bonafide work done in part fulfilment for First Year M.Sc, (Speech and Hearing) of the student with Register Number.

Dr.M.Nithya Seelan
Director,
All India institute of
Speech & Hearing,
Mysore - 570 006.

CERTIFICATE

This is to certify that this Independent Project entitled "Effect of Continuous Auditory Stimulation on the Averaged Reflex Threshold" has been prepared under my supervision and guidance.

Dr.M.N.Vyasamurthy
GUIDE

DECLARATION

I hereby declare that this Independent Project entitled "Effect of Continuous Auditory Stimulation on the Averaged Reflex Threshold" is the result of my own study under the guidance of Dr.M.N.Vyasamurthy, Department of 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.

Date: April 1986

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INTRODUCTION

Protection from noise induced hearing loss (NIHL) would be easily possible if there was a sharp demarcation between susceptibility and non-susceptibility. But it is known that there are individual differences in this respect. Researchers have endeavoured to develop suitable tests to differentiate the susceptible from the general population, with an aim of offering good protection and thus preventing NIHL.

The most commonly used tests are those based on the Temporary Threshold Shift (TTS) paradigm. The rationale for using this was based on Temkin's hypothesis.

Temkin suggested that the measurement of temporary change in hearing sensitivity following a brief but moderately intense acoustic overstimulation provides a simple valid estimate of permanent hearing loss due to noise exposure (Kamakshi, 1981).

The relation between TTS and NIHL is not simple. There are variables like the frequency, duration and intensity of both the exposure stimulus and the test stimulus, which effectively alter the resultant shift in threshold (Humes, and Bess, 1978). Ward (1968) said that the best predictor of permanent threshold shift (PTS) was the TTS resulting from exposure to that specific noise to which the individual is routinely exposed in his envi- ronment. This feature of noise specificity limits the clinical use of the TTS paradigm. So a single standard noise stimuli cannot be used for all the subjects. Hence, its use as an index of susceptibility has its limitations.

Humes and Bess (1978) tried to find an alternative to the conventional TTS paradigm. They examined the various psychophysical measures which are predictors of susceptibility to noise induced temporary threshold shift. The test comprised of three tests (1) Aural overload test (2) Critical intensity procedure (3) Loudness discomfort level.

This test battery did succeed in delineating 'tough' ear from'tender' ears. Further, the aural overload test was found to be a highly accurate predictor of TTS.

Humes (1977) suggests an ideal susceptibility test battery consisting of

(1) The aural overload test.

(2) The threshold of octave masking test.

(3) The critical intensity modified procedure.

(4) Word discrimination scores obtained in noise.

Studies have been carried out to show that the TTS is related to acoustic reflex (Borg, 1968, Brashner 1969 etc). This is because the reflex attenuates low frequency below 2000Hz by upto 20 dB. This is belived to act as protection against NIHL (Coles,196S As TTS is related to the intensity of the signal reaching the inner ear, if there is a reduction in the intensity due to the reflex action it should consequently reduce the TTS (Borg, 1968; Brashner, 1969).

Johansson et al., (1961), Miyakita et al., (1978) have found a relationship between the acoustic reflex (AR) and NIHL Zachariah (1980) found that acoustic reflex can be used as an index for susceptibility. She found that subjects with greater TTS exhibit low acoustic reflex threshold. Subjects with less TTS exhibit high reflex thresholds.

So subjects with low acoustic reflex threshold (i.e. susceptible ears) show greater TTS and greater magnitude of contraction of the stapedius muscle. Also, subjects ^ho demonstrate a high reflex threshold (i.e. not susceptible) show less TTS and less magnitude of contraction of stapedius muscle.

The fatigability of the stapedius reflex is another aspect which can be used as a predictor of susceptibility to NIHL (Nilsson et al 1980).

Kamakshi (1981) found that subjects with greater TTS had more adaptation and that a subject with less TTS had less adaptation. In a 'tender' ear both the mechanism i.e. hair cell and neural mechanisms are susceptible to NIHL.

Jagadish (1982) has found that the relation between acoustc reflex threshold and threshold of octave masking. Further, he found that the acoustic reflex were negatively correlated, so an individual with low acoustic reflex threshold will demonstrate a large magnitude of reflex. This is in agreement with Zachariah's(1980) study.

It is known that the functional state of the auditory system changes when the auditory system is continuously exposed to auditory stimulus. One of the methods to check whether the functional state of the auditory system has changed, following continuous auditory stimulation is threshold determination. This method has been widely used. However, there appears to be a new way by which one can measure the change in the functional state of the auditory system, following continuous auditory stimulation. That is, the measurement of averaged reflex magnitude. The measurement of averaged reflex magnitude, before and after continuous auditory stimulation would perhaps give an objective assessment of the functional state of the auditory system. The present study has been designed to find answers to the following questions -

1. Does the amplitude (magnitude) of the averaged reflex vary with the number of presentations of the stimulus, before the ear is continuously stimulated with an auditory stimulus?

2. Does the magnitude of the averaged reflex vary with the number of presentations of the stimulus, after the ear is continuously stimulated with an auditory stimulus.

3. What is the minimum duration of the continuous stimulation, after which the magnitude of the averaged reflex changes?

4. What are the physical parameters of the continuous auditory stimulus (such as frequency and intensity) which produces a change in the functional state of the auditory system (i.e. in terms of a change in the averaged magnitude of the reflex.

5. Do the normal subjects show individual differences in the magnitude of averaged reflex after the ear is continuously stimulated with an auditory stimulus?

6. Can the subjects who exhibit a change in the magnitude of the averaged reflex (after the ear is continuously stimulated) be considered as susceptible to NIHL.

Definition of terms used in this study:

1) Noise Induced Hearing Loss - any gradual diminution of hearing acuity associated with noise exposure.

2) Susceptibility for noise induced hearing loss - the likelihood of a person to develop noise induced hearing loss, if exposed to continuous excessive noise for a long period.

3) Temporary Threshold Shift - any post stimulatory shift and auditory threshold that recovers ever time or that which is temporary in nature. It is measured in dB.

4) Acoustic Reflex Threshold: the minimum a intensity of the stimulus which gives a noticeable deflection on the impedance instrument.

5) Averaged reflex - Refers to the averaged amplitude of reflex obtained for ten successive presentations of the auditory stimulus at acoustic reflex threshold.

6) Magnitude of reflex:- The magnitude of reflex refers to the deflection of the sound meter needle of the impedance instrument by atleast one division, when a stimulus is presented.

REVIEW OF LITERATURE

The Review of Literature for the present study deals with two important research areas:-

1. Tests for susceptibility to Noise Induced Hearing Loss(NIHL)
2. Studies using signal averaging technique.

There is no precise definition for susceptibility. It has been described as a characteristic that determines relative resistance of the: ear to both temporary and permanent change-

a) from long or short exposure
b) at high or low intensities
c) to high or low frequency stimulation
d) from tones, noises or impulses of any shape or spectrum, and
e) that is relatively invariant for an individual throughout his life span. (Ward, 1963).

Tests for detecting susceptibility of persons to Noise Induced Wearing Loss (NIHL):

Newby (1972) has classified the tests into three main groups.

(1) Tests based on Temporary Threshold Shift (TTS) measures.
(2) Tests based on aural harmonics distortion measures.
(3) Other tests with different rationale.

Tests based on TTS measures:- TTS is the most popular measure of NIHL. The test involves firstly, to determine the subjects threshold at some frequency (usually around 4KHz). Thereafter a fatiguing stimulus either a pure tone or wide band noise is presented for a prescribed period of time. The threshold is once again determined immediately after the cessation of the fatiguing stimuli.

Prediction of suceptibility are made on the basis of either the absolute threshold shift observed or in terms of the time required for the threshold to return the normal i.e. its preexposure level. The person who demonstrates a large amount of threshold shift or who requires a longer time for his threshold to return to normal, is then presumed to be the most susceptible to permanent noise induced hearing loss. If placed in a noisy environment. The Table-1 shows some of the proposed tests and their criteria.

Wilson's modified test has a test frequency of 4KHz rather than octave of 0.25 KHz and the duration of the fatiguing stimulus is 5 minutes rather than 8 minutes.

A multifactor test was given by Ward (1963) which involves the determination of the growth of TTS after two or more values of (1) exposure time (2) recovery time.(3) exposure frequency (4) exposure SPL (5) test frequency (6) interruption rate (for intermittent noise) (7) pulse repetition rate (for impulses) can also be included in the test.

Table-1:

Report	Exposure			Recovery time (min.)	Test Frequency KHz
	Stimu-lus (KHz)	Level (dB)	Dura-tion (min.)		
1. Peyser(1940)	0.25	80(HL)	0.5	0.5	0.25
2. Wilson(l943)	0.25	80(HL)	5	1	Octaves of 0.25
3. Peyser(1943)	1	100(HL)	3	0.25	1
4. Theilgaard (1949)	0.5, 1, 2 & 4	100(HL)	5	5	Half Octave above exp.
5. Theilgaard (1951)	100	100(HL)	5	5	1.5
6. Tanner(1955)	1	100(HL)	5	"Immedi-ately"	1
7. Theilgaard, according tc Greisen	1.5	100(HL)	5	5	2
8. Wilson(1944)	2	80(HL)	8	1	octaves of 0.25
9. Harris(1954)	2	97 SPL	5	Para-meter	4
10. Palva(1958)	2	30 SL	3	2	2
11. Van Dishoek (1956)	2.5	100(HL)	3	0.25	all (sweep)
12. Greisen (1951)	3	80 & 90(HL)	5	5	4-
13. Jerger & Carhart (1956)	3	105 SPL	1	Para-meter	4
14. Jerger & Carhart (1956)	3	100 SPL	1	para-meter	4.5
15. Wheeler (1950)	Noise	105 SPL	30	Para-meter	2, 4, 6

Table-1 contd..

16. Gallagher & Goodwin (1952)	Noise	115(HL)	10	"Immedi-ately	2, 4, 6
17. Ruidi(1954)	Noise	Para-meter	3	2	4
18. Falconnet et al(1955)	Noise	100 SPL	3	Para-meter.	3
19. Christiansen (1956)	Noise	105 (HL)	3	0.5, 15	4
20. Ward(1967)	Noise 0.7 - 5.6	120 SPL (mon-aural)	1	2	1.7 to 5.6
21. Harris(1967)	Noise Noise Noise 4 4 1	110 SPL 110 SPL 110 SPL 90 SPL 90 SPL 110 SPL	1 3 10 5 25 1	: 2 2 2 2 2	1 4 4 4 4 1

Kryter (1970) is of the opinion that the pure tone and broad band noise tests of TTS_2, proposed by Ward (1967) and Harris (1967), plus a TTS_2 test for impulsive sounds would be appropriate for evaluating possible, susceptibility to NIHL. It also seems logical to score these tests in terms of HL- plus TTS_2 as an index of susceptibility. The test and retest results should be combined to give better estimation of susceptibility. The rationale for such a test, in general is based on the assumption that the ear most susceptible to TTS, other things being equal, is the most likely to suffer some permanent damage. In general, while the relation between noise exposure and TTS and noise exposure and permanent threshold shift may be similar, it has been difficult, to demonstrate that the person most susceptible to TTS is like-wise the most susceptible to NIHL. Some possible explanations for this has been suggested by Kryter (1979).

(1) Susceptibility to TTS within individual from a given tone or band of noise is not too highly correlated with the TTS found from exposure to a different tone or band of noise Ward (1967) mostly because the hearing level at different frequencies would have as long as 35 dB range in 'normals' (i.e. the range is from 10 to 25 dB HL re.IS0)[Ward, 1967].

(2) The noise in industry may be but one of the noises to which men are exposed to in their daily lives, thereby introducing some incertainity and variability in the data.

However, not being able to prove a strong correlation between the results from the susceptibility tests and eventual NIHL, does not mean that some persons do not have ears that are more resistant to damage than others. Kryter (1970), Jerger and Carhart (1956), Kryter (1960), studies give evidence for the provisional acceptance of a relation between TTS and permanent damage.

The general postulate reached by Kryter et al., (1966) after analysis of the available data is that the average permanent threshold shift (PTS) resulting from nearby daily exposure, 8 hours per day for about 10 years, to a particular noise, is approximately equal in dB to the average TTS_2 produced in young normal ears by an 8 hour exposure to same noise.

Tests based on Aural Harmonics: Lawrence and Blanchard (1954) suggested a test based on Aural Harmonics with a predictive value. This test attempts to determine the minimum intensity at which the response of the ear to a particular frequency becomes distorted or non-linear, and produces harmonics. It is assumed that, at some point as intensity is increased the ear will be unable to respond without distortion. This distortion is manifested by the production of aural harmonics (multiples) of the stimulating frequency.

When a 2nd tone which is almost exactly twice the frequency of the original tone, is presented to the ear, the aural harmonics are detected. If the harmonics is being generated within the ear, the probe tone will interact with the aural harmonics to produce the sensation of beats. Wegel and Lane (1924) studied the threshold of aural overload using best beat method.

Clark and Bess (1969) reported the variation of the method to determine the presence of aural harmonics and called it TOM test (Threshold Octave Masking test), where the tone-on-tone masking technique was used.

The assumption behind this test being predictive of susceptibility is that when an ear is driven into nonlinearity by high intensity stimulus and this condition producing distortion is allowed to persist for any considerable time duration, a breakdown in the auditory system will occur. The earlier nonlinearity occurs, the lower the intensity of the stimulus required to produce breakdown in the auditory system. Lawrence and Blanchard (1954) assumed that subjecte- who have comparative low threshold of nonlinearity are therefore more susceptible to NIHL. These assumptions were confirmed by the laboratory experiments on guinea pigs. The animals that showed the lowest thresholds of non-linearity sustained the greatest losses after exposure to noise, those who showed the highest thresholds of overload, sustained least losses, following exposure(Newby, 1972).

The ear generates overtones called aural harmonics (AH) when the mechanisms within the cochlea (Wever and Lawrence 1954) are forced to vibrate beyond their capacity for simple proportionate responses. At the same time the fundamental signal also causes the ear to lose sensitivity for the higher frequency. This reason aural harmonics are not heard as separate perceptual entities at moderate signal intensities even though their presence is detectable using special psychophysical procedure.

The best beat method is the most common of these procedures. With this method* clinical investigators have measured the lowest intensity (in dBSL) of the pure tone F_0 (f_1) required to mask the second aural harmonics just detactable. This threshold of distortion has been related to inner ear pathology (Lawrence and Yantis (1956) to the estimation of cochlea reserve in otosclerotic ears (Yantis and Magielski(1958)to the intelligibility of speech in patients with sensory neural impairment (Yantis et al., 1966),and possibly even to the determination of susceptibility to acoustic trauma (Lawrence and Blanchard, 1954). Inspite of its potential significance in hearing conservation and the diagnostic evaluation of hearing disorders, otologists and audiologists do not utilize the best beat method as a regular clinical tool. The neglect may be due to certain practical as well as theoretical difficulties. One aspect of the latter is the problem of masking at the octave interval and its complicating effect upon resultant measurements (Jagadish, 1980).

Clank (1967) using a different procedure has indicated that the amplitude of aural harmonic is below the perceptual threshold when the ear's distortion begins and grows at a rate equal to or less than the masked threshold for intensities below 70 dBSL. So the aural harmonic levels by the best-beat method might be essentially equivalent to the masked threshold measured in the immediate frequency vicinity of the aural harmonic.

Two separate experiments were carried out to test this hypothesis. In the 1st experiment normal ears were tested and threshold of masking and aural harmonic threshold levels were obtained. In the 2nd experiment the masking threshold from a group of sensory neural impaired listener, were compared to the aural harmonic threshold obtained by previous clinical investigations using the best-beat method.

On the results of this experiment Clark and Bess (1969) concluded the following:-

In the first experiment, the threshold of masking was shown to be equivalent to the aural harmonic threshold level in normal ears. The second experiment reveals that even when the ear is impaired by sensory neural disease processes, the threshold of making (TOM) is affected in the same way as the aural harmonics threshold. Thus this gives proof that the best beat method and the tone-on-tone masking procedure measure the same phenomenon.

TOM test was administered to normals and sensory neural listeners by Olsen and Berry (1979) at four test frequencies viz. 500Hz, 1KHz, 2KHz, and 4KHz. The TOM value was found to be universely proportional to the degree of hearing loss at the masker frequency results indicate that the TOM is capable of distinguishing subjects with sensory neural involvement from those with normal hearing. Once the influence of hearing loss is over come at high intensities the sensory neuralear performs essentially the same as the normal ear in a tone-on-tone masking test.

Grimm and Bess (1973) study has suggested that the TOM test can be used as a substitute for measuring aural harmonic thresholds. The results show that the TOM test can differentiate subjects with cochlear involvement from normal hearing subjects at all three masker frequencies (500Hz, lOOOHz and 2000Hz). Also the test has a high test, retest reliability.

III. <u>Other tests</u>:- The applicability of the acoustic reflex to evaluate an individual's ear Susceptibility was proposed by Johonnsen et al., (1967). The subjects with low ART showed a long temporary loss of hearing after exposure to noise. They concluded that people with good middle ear reflexes had tougher ears.

Huizing (1949) reported that subjects with recruitment were more susceptible to noise induced hearing loss then normals.

Humes and Bess (1978) have designed a test to examine the individual differences among\Various psychophysical measure that have been known as potential predictory of TTS and auditory fatigue. It is as follows:-

1. Aural overload test (Lawrence and Blanchard, 1954).
2. Loudness discomfort level (LDL) Hood (1968) has suggested that LDL may be related to the amount of post stimulatory fatigue an individual incurs.

LDL was measured at frequencies 500, 1000, 2000, and 4000Hz as recommended by Mergen et al., (1974).

Further TTS at 0.75 and 3 KHz was recorded from 0 to 3 minutes post exposure, following 3 minutes exposure to 0.5 and 2000Hz pure tones at 100 dB SPL

3. The critical intensity (CI) procedure was proposed by Ruedi (1954) and later used by Ward (1968). The original CI test consisted of exposing the subject to a fatiguing stimulus which increased in levels until a criterion amount of TTS was observed. The only time internal between successive exposures was that used for threshold determination. No recovery period was thus employed.

A modified procedure was used by Humes and Bess. They determined the CI at which maximum TTS shifts upwards in frequency from the exposure frequency to one half octave above the exposure frequency and they allowed a recovery period.

To assess susceptibility to TTS they used broad band noise and pure tones of both high and low frequencies.

Their results suggest that both the test were sensitive to detect individual difference in TTS and hence even in susceptibility.

Mustain and Schoeny (1980) conducted a study on 56 normal subjects to explore psychoacoustic correlates of susceptibility to auditory fatigue.

They used the following fatigue tests:-

1) A 3 minutesexposure to a 110 dBSPL pure tone of 2000Hz. TTS was measured at 4 KHz. This was the high frequency test.

2) A 3 minute exposure to a 115 dB SPL tone of 500Hz. Here TTS was measured at 1 KHz. This was the low frequency test.

Next, the amount of TTS and TTS recovery were compared with performance on a test battery consisting of -

a) A masking level difference test

b) Brief tone audiometry

c) Speech discrimination in noise, and

d) Threshold of octave masking test.

The results indicate a relationship between susceptibility to auditory fatigue and TOM. This is expected because of the demonstrated correlation between TOM test results and threshold of aural overload and also in view of the relationship between aural overload and TTS. These have been demonstrated physiologically and psychoacoustically.

One study reported a negative correlation between TOM test for a 4 KHz masker and amount of TTS following a 5 minute exposure to broad band noise at 110 dB SPL(Humes et al.,1978) Their study also suggested a relationship between amount of TTS and brief tone audiometry results. The implication here is that persons showing larger, TTS tend to have flattened threshold duration function for selected frequency.

Speech discrimination and masking level difference failed to show any consistent relationship to any of the high or low frequency test variables. The identification of psychoacoustic tasks which correlate with susceptibility to TTS would be for several reasons.

1. These psychoacoustic tasks could be used as new indices of susceptibility to NIHL replacing traditional TTS based test.
2. If several correlates could be identified they could be used as test battery for susceptibility testing.
3. The identification of psychoacoustic correlates of TTS can also give information on the areas of the auditory system e involved in the fatiguing process. Thus the site of lesion of auditory fatigue can be deduced.
4. A test battery comprised of psychoacoustic correlates of susceptibility to TTS may be useful in detecting minimal auditory

dysfunction. It is generally accepted that pure tone audiogram is a poor indicator of the histological status of the auditory system especially the cochlea. As in other auditory pathology the eventual damage shows in a pure tone hearing loss (Hawkin,1973) If auditory pathology is to be detected before irrepairable damage results then new tests which are sensitive to subtle dysfunction have to be used. Indices of susceptibility to auditory fatigue can be considered more discriminating measure than are pure tone threshold. This is because persons with identical thresholds show different amounts of TTS following similar periods of exposure.

Ward (1963) is of the opinion that there may never be a single index for universal susceptibility. For such an index to be accepted there should be high correlation of (1) TTS at two different recovery times. (2) TTS at one frequency and that at another. (3) TTS produced by impulse and that produced by noise etc.

It is seen that often there exist a correlation which are generally not high.

Ward (1965) conducted a study to review the concept of susceptibility to hearing loss following continuous exposure and concluded that susceptibility is normally distributed. Bishnoi(1975) studied the distribution pattern of susceptibility to NIHL in Indian population. He used Wilson's test to determine the degree of susceptibility.

Studies using signal averaging technique:

The application of signal averaging technique in the study of acoustic reflex is quite recent. The need for signal averaging was not apparent to investigators concerned with its clinical application "because of its robust nature". Earlier the instruments used for the measurement of the acoustic reflex threshold achieved adequate signal/noise resolution by relatively narrow band pass filtering of the probe tone. As more sophisticated application for the acoustic reflex were proposed, it became apparent that potentially valuable information could be obtained from careful examination of temporal characteristics of the reflex such as latency (Borg,(1982)clemis, Sarno,(1980); Jerger and Hayes (1983); Manghan et al., (1980), Norris et al., (1974); Ruth and Niswander, (1976). Onset rise time (Gorga et al.,(1974) Laaskinen, Roose (1974); and Miller (1974), offset decay characteristics (Letien and Bess, (1975); Norris, (1975), stelmachowicz and Taylor (1974). (Stach and Jerger 1984}

"In this context, however, the narrow band filtering used to minimize background noise level sacrificed temporal resolution to an undesirable degree (Clemis and Sarno, 1980; etc)" (stach and Jerger, 1984).

Clinical investigations has also revealed that potentially valuable diagnostic information lay in the relations among acoustic reflex threshold for signals of varying frequency and band width. Threshold differences of a little as 2 or 3 dB were of potential clinical significance. (Hall and Bleakney, 1981? Jerger and Mauldin and Crump, 1974; Margolis and Fox, 1977; (stach and Jerger, 1984).

These two developments. i.e. the need for better temporal resolution and the need for more accurate threshold delineation provide a rationale for the use of signal averaging technique ia the measurement of acoustic reflex threshold. Thus the main advantage of this technique according to stach and Jerger is that "it makes it possible to achieve adequate signal/noise resolution without the need for narrow band filtering of the probe tone and its subsequent temporal distortion of wave form morphology. Also, avaraging technique provides a more precise definition of ART levels by enchancing signal definition against the noise background characterizing a threshold region".

The signal averaging technique has been used by Stach and Jerger 1984 to study the threshold and suprathreshold characte-ristics of the acoustic reflex. Their results indicate that (l) "Many supposed reflex threshold and latency aberration are actually amplitude abberation that are inappropriately classified because of instrumentation constraint (2) reflex amplitude and waveform morphology can be recorded with appropriate fidelity using a signal averaging technique. (3) problems due to absolute amplitude variability can be minimized by using an index technique to assess amplitude relationships (4) amplitude indices are sensitive indicators of neural pathology (5) signal averaging and suprathreshold measurement of reflex amplitude and wave form morphology promise to enhance the sensitivity of acoustic reflex measurement".

The benefit which has been obtained from the use of signal averaging has given a much wider understanding on the nature of pathological effects on the acoustic reflex latency and threshold alterations can no longer be thought of as resulting from pathology, alone, but may instead be effects that occur secondarily as a result of amplitude or morphological changes (stach and Jerger, 1984).

Jerger, Mouldin, Lewis (1977) studied the interaction of signal intensity^signal duration in normal listeners, at visual detection threshold (VDT). The signal averaging technique was used. They found that reflex amplitude increases with signal Intensity at a rate which changes as a function of signal duration. This finding complicated the interpretation of temporal summation data based on VDT.

In another study measurement of the threshold and growth function of the acoustic reflex in man were made using the signal averaging technique. They used pure tones 250, 500, 1000, 2000 and 4000Hz and Broad Band Noise was the contralateral stimuli. They varied the intensity level from reflex threshold to 116 dB SPL. The acoustic conductance and susceptance components of admittance, at 220 and 660 Hz were used to measure the reflex activity. They reported their results as changes in conductance, susceptance and admittance in cg . The ART were found to be similar to those reported in other studies. The 220 Hz probe resulted in thresholds that averaged 3.5 dB higher than those obtained with the 660Hz probe the broad band noise and lOOOHz stimuli produced the longest reflex magnitudes, while the smallest were observed with 250-4000Hz signals. The dynamic ranges of the restricted growth functions were frequency dependent for pure tones and ranged from >16dB at 250 Hz to >28 dB at lOOOHz, while that for noise was >50 dB. (Wilson and McBride, 1978)

Hall (1982) studied the efrect of age and sex on AR amplitude controlling for hearing sensitivity, ear canal volume, static compliance and minor middle ear dysfunction. He used 92 subjects age ranging from 20-80 years 45 males and 47 females. He found that age influenced acoustic reflex amplitude i.e. as age increases amplitude decreases. This is in/with Gersdorff's(1978) finding. He found maximum reflex amplitude over the range of 20-80 years which decreased by 56% on an average. Although both contra and ipsilateral reflexes were equally affected the age related amplitude changes were usually more in contralateral measurements. In young subject, the ratio of contra to ipsilateral maximum reflex amplitude was approximately 1:40. Comparatively larger uncrossed reflex amplitude is seen in younger groups.

He also found a distinct interaction between age and sex. In young subjects (20-30 years) there was no significant difference in reflex amplitudes in females vs males, except with respect to noise signal. In the 60-80 years age group, contra and ipsilateral amplitude, was significantly larger in females than in males for all signals. In younger group, maximum amplitude in males was approximately 80% of the amplitude in females, while in the older group, maximum amplitude in males was only 64% of female amplitude.

In another study in 1982 Hall, measured the contralateral and ipsilateral acoustic reflex amplitude in 99 adults. The same signal averaging appratus was used. He found that minor unsuscepcted middle ear dysfunction profoundly influenced acoustic reflex amplitude. Reflex amplitude in subjects with minor impedance abnormality was, on the average, reduced by 68% compared to amatched control group. There was a complex relationship between age, sensorineural loss, signal band width and acoustic reflex amplitude. Sensorineural hearing loss differentially influenced acoustic reflex amplitude for young vs older subjects.

Jerger et al., (1978)tested 26 subjects with normal hearing bilaterally to study the acoustic reflex amplitude in ears with normal hearing. They used subjects with age range from 20-52 years. They measured reflex using signal averaging technique. Four reflexes were elicited two contralateral and two ipsilateral over the intensity range of 60-110 dB SPL . Their results showed that ipsilateral reflex amplitude is slightly greater than the contra-lateral reflex amplitude both for 1KHz and broad band noise. This is in agreement with Miller (1961, 1964) and Borg (1968, 1972, 1973) findings. secondly, they found amplitude of the broad band noise reflex is greater than that of the 1KHz reflex. And lastly, the reflex amplitude grows as a monotonic function of signal level (Jerger et al., 1978).

Moreover, in these normal ears, the shape of the amplitude function is sigmoidal, not unlike the integral of the normal probability density function. As signal level decreases, each amplitude function shows a gradual 'tailing out', below 90 dBSPL for the lOOOHz tone and below 80 dBSPL for the broad band noise. Only a sensitive instrumentation can expose this (Jerger etal., 1978).

In this study there were 15 subjects who showed aberrant pattern. These patterns were of two kinds, either ear symmetry of all reflex amplitudes, or inter-ear reversal in the expected ipsilateral -contralateral relationship was seen. They speculate that these aberrationsmay be due to minor middle ear dysfunction. They suggest that these subtle middle ear disorder is not suffi-cient to elevate either audiometric or reflex threshold, hut only effects reflex amplitudes at high levels.

To demonstrate that such subtle effects can modify the reflex amplitude they tested three normal subjects while varying air pressure in the external auditory meatus. signal level was held constant at 100 dB SPL. For all conditions results were given as reflex amplitude in percent relative to reflex amplitude for that condition at 0 mm of water. Except for a slight enhancement at -50 mm of water the effect of either positive or negative pressure is to produce reduction in reflex amplitude. In the contralateral condition there is a "pure effect" of negative pressure on transmission efficiency since the probe ear has not been altered. The 1KHz pure tone reflex amplitude is uniformly more affected than the broad band noise reflex amplitude.

In ipsilateral condition they found a combined effect of reduced sound transmission and reduced effectiveness of stapedius muscle contraction. Reflex amplitudes were lower, but the differential effect on tong and noise remains. Thus, they concluded that even a very minute change in middle ear status can eause a reduction in reflex amplitudes at high signal levels.

Jerger et al., (1978)also studied the effect of sensorineural loss an acoustic reflex amplitude using signal averaging tech nique. They tested 21 ears of 13 patients with relatively flat audiometric configuration. They expected superiority of ipsilateral to contralateral reflexes appemrc and the noise reflex amplitude to be larger than the tone reflex amplitude, but this difference is greatly reduced. Further, the absolute size of all reflexes is somewhat smaller than in normal groups at comparable signal levels.

The most striking difference between normal and flat sensorineural cases, is the change in the shape of the reflex amplitude function. The general sigmoidal shape and especially the "tail" at low intensity levels is absent in sensorineural group. Instead they show almost linear function for both tone and noise reflex activity stimuli, Where as the normal group showed a substantial advantage for noise in the"tail" region. While the noise tone difference is smaller in the sensorineural than in the normal at all levels, the effect is more obvious at low signal levels which is close to reflex threshold. This finding is contradicting the possibility that suprathreshold indices of reflex amplitude may yield more accurate predictions of sensorineural hearing loss than prediction based on threshold differences.

Effect of the degree of hearing loss on reflex amplitude was also studied by Jerger et al., (1978) using signal/averaging. They regrouped the 51 sensorineural cases according to pure-tone average. All degrees of hearing loss show about the same reduction in reflex amplitude. Even the relation between degree of loss and broad band noise reflex amplitude show no correlation.

Investigators have shown that only acoustic reflex amplitude is affected by retrocochlear dysfunction and theother conventionally measured thresholds are uneffected. (Borg, 1973,'36, Colletli, 1975). Using amplitude characteristics various auditory disorders can be identified. Hayer, Jerger (1982) wanted to evaluate the diagnostic significance of suprathreshold acoustic reflex, amplitude characteristics. They employed simultaneous measurement of the crossed and uncrossed acoustic reflex and a signal averaging technique. They came to a mathematical model based on known afferent, efferent and central pathway effects by which they are able to compare results from a variety of patients and to make diagnostic interpretation.

Temporal aspects of the acoustic reflex response were estimated for 3 groups of subjects viz. normal hearing subjects, subjects with NIHL and children with sensorineural loss. They measured onset latency and rise/fall times of admittance changes using averaged responses. The/stimulus was tone bursts of 250 msec, duration and 10ms. rise/fall time. Frequency was varied from 500Hz to 4KHz.

No differences between groups were observed for onset responses. Subjects with NIHL showed slightly longer offset responses but children with sensorineural loss showed longest offset response. Thus acoustic reflex offset latency may be a useful screening device.

Draf and Leitman (1972) opine that only by using computer averaging of the reflex response, can the measurable threshold of reflex activity be lowered by 10-15 dB(Sesterhenn and Breuninger 1976).

Jerger, Burney and their associates found that signal averaging procedure produced slight threshold levels, but did not effect a noticeable change in its predictive accuracy of hearing loss.

METHODOLOGY

SUBJECTS:

16 normal hearing subjects in the age range of 18-22 years were selected for the study. They were divided into 3 groups. They were randomly selected from the student population of All India Institute of Speech and Hearing.

A subject was selected after he/she fulfilled the following criteria:-

1. He/she had no otologic problems such as ear discharge, tinnitus earache, or any other otologic problem before or during the testing.

2. He/she has a normal reflex threshold.

3. He/she could tolerate 100 dB tone for 1 minute or 2 minutes duration without any complaint of headache or giddiness.

4. He/she had hearing within normal limits.

EQUIPMENT:

1. The Madsen ZO-174 Immittance Audiometer with TDH-39 earphones.
2. A Madsen Electronics Portable Impedance Audiometer ZS-77-MB with TDH-39P earphones.
3. A stop watch.

Brief description of the Madsen ZO-174.

Instrumentation:

The Madsen ZO-174 Immittance Audiometer was used to measure the averaged reflex threshold. It is a computerized instrument which uses microprocessor technology to provide a very versatile measurement system.

It has the following features:

1. Calibration data are stored without requiring battery back up, and calibration can be performed by the user.
2. Inspilateral stimulus calibration can be automatically adjusted to compensate for different ear canal volumes.
3. The ZO-174 is a modular system which includes the immittance audiometer, with optional Monitor and Printer. The system can be arranged in various physical configurations for the convenience of the ear.
4. It features manual and automatic operation modes. In the automatic modes, rapid automatic tympanograms and AR can be obtained. Refined manual testing can be done to take a "closer look" at tympanogram or reflex information.
5. The user is continually aware of the operation made by screen prompts on the monitor, and the mode information is retained on the print out.
6. Three probe tone frequencies are standard on the ZO-174; 226 and 1000 and either 660 or 800Hz. The higher frequencies enable the measurement of tympanogram and contralateral AR in adults and new borns when high frequency probe tones may yield more information than the traditionally low frequency probe tone.

7. Acoustic reflex stimuli include pure tones, pulsed pure tones, click trains and broad band noise. There is also an external input available for contralateral reflex stimulus.

8. Dual stimuli can be presented either bilaterally or through the stimulus earphone. This makes it passible to measure the sensitization effect of a pre-activating signal on the acoustic reflex threshold.

9. In the Tympanogram and Reflex (T & R) mode (with probe tone of 226Hz only), the Z0-174 will seek and record the contra or ipsilateral acoustic reflex thresholds at 500 to 4000Hz.

10. In the Expanded Reflex (ER) mode at 226Hz probe tone, the ZO-174 will record contralateral or ipsilateral acoustic reflexes at 2 selectable frequencies on a 2 second time scale.

11. The Average (Avg) mode uses the capabilities of the ZO-174 microprocessor to average multiple presentations of acoustic reflex elicitation on a two secona time scale. Averaged reflexes reduce the effects of noise and movement artifacts.

12. The Decay mode provides for the recording of contralateral or Ipsilateral acoustic reflex decay on a 12 second time scale.

13. In all modes, acquired results can be reviewed on the monitor before printing. If some of the acquired results need to be repeated, this can be done before printing. Any of the modes can be interrupted with the STOP/RESET feature.

14. A serial interface to computer is an option, permitting storage of results and/or remote control of the ZO-174.

CALIBRATION:

Contralateral stimulus calibration -

The earphone TDH-39 delivers the stimulus for contralateral reflexes. The pure tone was calibrated in dBHL (re.ANSI,1969) using a standard 9A coupler and precision sound level meter with an octave filter. 90 dBHL was used as the calibrating level so that ambient noise has less effect on the accuracy of the readings Next, 'calibrate mode' is selected and dB window showed 90 dB. The appropriate SPL readings were got by using the following correction factors for HL.

500 Hz	add	11.5
1000 Hz	add	7.0
2000 Hz	add	7.0
4000 Hz	add	9.5
6000 Hz	add	15.5
8000 Hz	add	13.0

TONE CONTRA:

The ZO-174 is is kept in calibrate mode', then frequency button WAS pressed for the frequency to be calibrated. Contra level buttons are used to set SPL on the sound level meter to match the 90 dB HL showing in the dB display.

TEST ENVIRONMENT:

The average reflex measurements was carried out in a one room situation of a sound treated room. The audiological evaluation was done in a two room situation of a sound treated room.

The magnitude measurements were carried out in a quiet room only instruction given to each subject was "please sit still and do not swallow".

PROCEDURE:

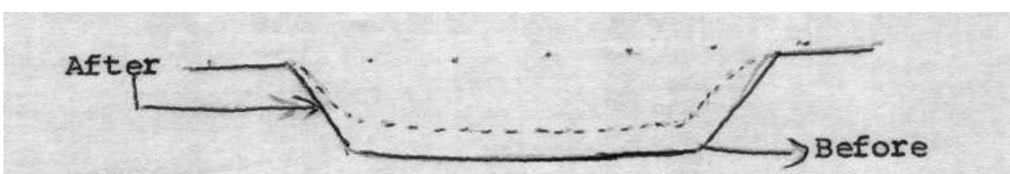
Experiment-I: To measure the averaged reflex threshold of the right ear before and after 1 minute or 2 minute continuous stimulation.

Subjects were divided into 3 groups Group-1 consisted of 7 subjects who were exposed to a 1KHz tone for 1 minute at 100 dB HL.
Group-II consisted of 5 subjects. They were exposed to a 2KHz tone for 1 minute at 100 dB HL.
Group-III consisted of 5 subjects, who were exposed to a 1KHz tone for 2 minutes at 100 dBHL.

1. The immittance audiometer was calibrated according to instructions in the manual.
2. The probe was placed in the right ear and the phone on the left ear.

3. Air tight seal was ensured before further measurements were carried out.
4. The frequency selector was pressed and 1 KHz was selected.
5. The intensity selector was pressed to and a 100 dB HL tone was presented to get a recordable reflex curve.
6. The 'R & T' selector was pressed and a#hJM? the tympanogram and reflexes appeared on the screen.
7. The 'AVG' selectors was pressed, following which the 'Auto start' was pressed.
8. After 2 averaged reflexesaare traced the CONT button was pressed until 10 reflexes were averaged.
9. The amplitude of reflex was traced.
10. Next, a continuous tone of 10 dB HL was presented through the earphones. Simultaneously a stop watch was started. After a minute the tone was stopped by pressing "Stop Reset".
11. Immediately, the 'AVS' button was pressed and again 10 average reflex were recorded. The amplitude of the reflex was again traced by a dotted line.

eg:-



In a similar manner the average reflex magnitudes were got for the 3 groups of subjects.

Experiment-II: To find the magnitude of reflex at threshold and 10 dBSL (Ref.ART) usiag the Madsen Impedance Audiometer ZS-77-MB.

The same three groups of subjects were tested in the right ear.

PROCEDURE:

Calibration check (as per the manual instructions).

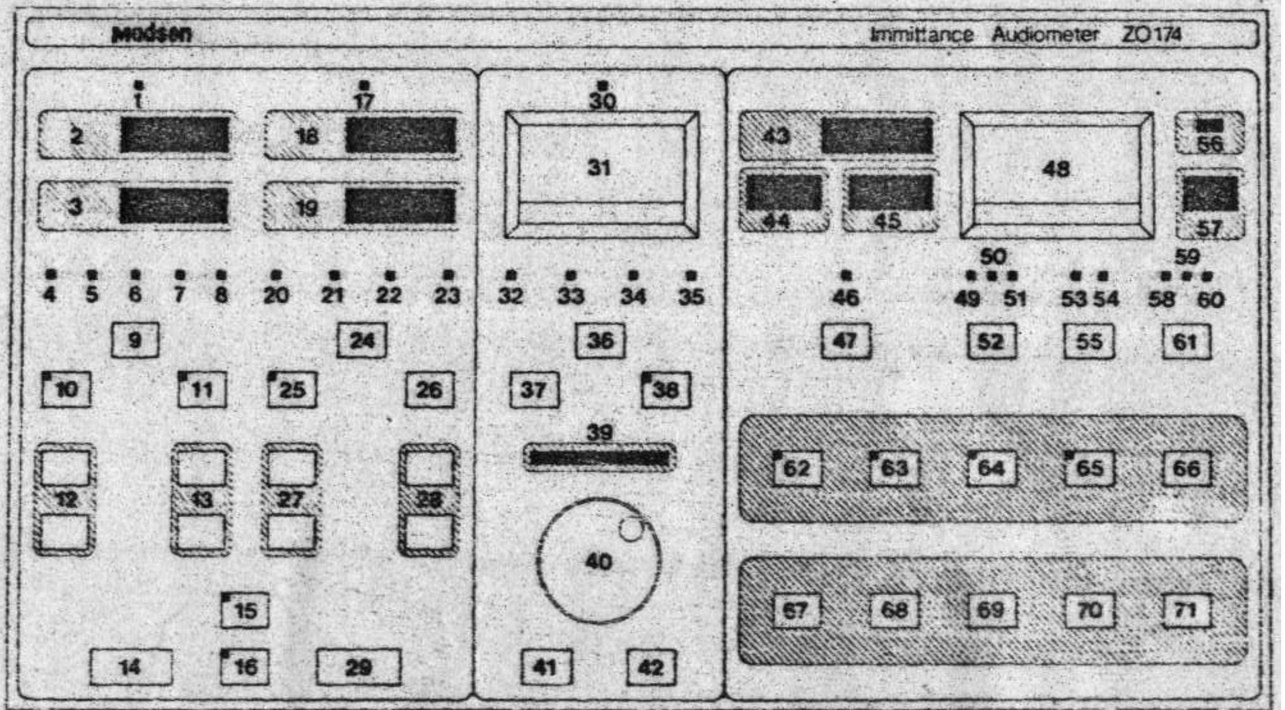
Manometer Zero - To zero the monometer the air release button was depressed and the manometer adjust control was re-set on the rear panel. The instrument had to be warmed up for 10 minutes.

Step by step Procedure:

1. The earphones was placed on the left ear and probe in the right ear with a suitable probe tip.
2. An air tight seal was obtained.
3. Pressure was varied from +200 to -200 mm of water and the point of maximum compliance was taken as the middle ear pressure.
4. Keeping the ear under middle ear pressure the "Reflex" button was depressed.
5. The output selector was kept at position 'C (contralateral).
6. The magnitude (in terms of number of divisions) was noted down.

7. Frequency selected was 500 Hz and the minimum intensity to produce a minimum deflection. of '1' division in the balance meter was determined This level is considered as ART. The magnitude of deflection was noted down.
8. After determining the ART (the minimum intensity level required to produce a deflection of '1' division or more in the Balance meter (BM) and after noting down the actual deflection, the magnitude of reflex (i.e. the deflection of BM needle) was noted down at 5 dBSL and 10 dBSL (ref.ART).
9. Using the above procedures, the magnitude of reflex at 5 dBSL and 10 dBSL was determined for the frequencies: 1KHz and 2KHz.

9.0. ZO174 KEY NUMBERING SYSTEM



Control/Indicator:

(1) ON

(2) Frequency
Hz

(3) Level
dB

(4) (5) (6) (7) (8) - indicate which contra stimulus has been selected.

(4) TONE

(5) PULSING

(6) CLICKS

(7) NOISE

(8) AUX.INPUT.

(9) Select

(10) Ext. Range

(11) 1 dB

(12) LEVEL

(13) FREQ

(Frequency)

(14) INTEREPTER

(15) FAST RISE AND DECAY

(16) LOCK

(17) ON

(18) Frequency
Hz

(19) Level
dB

(20) (21) (22) (23) - Indicate which IPSI stimulus has been selected.

(20) TONE

(21) TDM (Time Division Multiplex)

(22) CLICKS

(23) TONE CONTRA

(24) SELECT

(25) 1 dB

(26) OPTION

(27) LEVEL

(28) FREQ(Frequency)

(29) INTERRUPTER

(30) LEAK

(31) PRESSURE

(32) (33) (34) (35) - Indicate pump speed

(36) Pump speed

(37) AIR RELEASE

(38) EXT RANGE

(39) Red light bar indicator for position of pump.

(40) Manual pump control

(41) (42) - Change air pressure

(43) PRESSURE
DIGITAL DISPLAY

(44) GRADIENT
DIGITAL DISPLAY

(45) STATIC COMPLIANCE
DIGITAL DISPLAY

(46) ON

(47) DPM(Digital Pressure Meter)

(48) COMPLIANCE METER

(49) (50) (51) - Selected sensitivity for tympanometry

(52) TYMP

(53) (54) - Sensitivity for reflex

(55) REFLEX

(56) POWER

(57) COMPLIANCE
DIGITAL DISPLAY

(58)(59) (60) - Probe tone in used

(61) PROBE TONE

(62)T&R (Tympanometry and Reflex)

(63) E.R (Expanded reflex)

(64) AVG (Averaging)

(65) DECAY

(66) PRINT

(67) AUTO START

(68) STOP/RESET

(69) CONT(Continue)

(70) ERASE

(71) DATA XMIT

(72) Controls power

(73) Sets zero on the manometer.

(74) Slow/fast switch provides damping of the system.

RESULTS AND DISCUSSION

Table-1 shows the magnitude of averaged reflex before and after continuous auditory stimulation using 1KHz tone at 100 dBHL for one minute duration. The last column shows the change (i.e. decrease) in magnitude after continuous stimulation. The results show that four out of the seven subjects show a change in magnitude. Three subjects did not show any change.

Table—2 shows the magnitude (amplitude) of the averaged reflex of subjects before and after continuous stimulation by a 2KHz tone at 100 dBHL for a duration of one minute. From the column showing the difference between the magnitude it is obvious that four subjects out of the five subjects show a decrease in magnitude following continuous auditory stimulation.

Table-3 shows the magnitude of averaged reflex before and after continuous stimulation by a tone with the following physical parameters. Frequency of 1KHz and intensity of 100 dBHL for a duration of 2 minutes. The readings in the last column show that two subjects out of five subjects show a change in magnitude after continuous auditory stimulation.

The above mentioned Tables show that averaged reflex does not vary with the number of presentation of the stimulus before continuous auditory stimulation. But it does change after continuous auditory stimulation.

It can also be inferred that the subjects tested, reacted differently to continuous auditory stimulation. For a stimulus with particular physical parameters there are individual differences with regard to the change in magnitude. Different physical parameters of the stimuli bring about change in magnitude of reflex in different subjects. Similarly, there are individual differences in the response of the ears to noise.

In Table-4, 5, 6, the magnitudes of reflex for the same 17 subjects are tabulated. The test frequencies were 500Hz, l000Hz and 2000Hz. The magnitude was measured in terms of the deflection of the balance meter needle of the Madsen Impedance Audiometer

The magnitude of each frequency is the difference between the magnitude of reflex obtained at 10 dBSL and the magnitude of reflex obtained at threshold level.

Table-4 gives the magnitude of reflex of the subjects of Group-1. The averaged magnitude of the 3 test frequencies are calculated. Three subjects out of the seven subjects show a large(averaged)magnitude of reflex.

Table-5 shows the magnitude of reflex for the three frequencies of reflex for the three frequencies for the subjects of Group-2. Comparing the averaged magnitudes of the 3 test frequencies it is clear that 2 subjects out of three subjects show a large (averaged) magnitude of reflex.

Table-6 shows the magnitude of reflex for the three test frequencies for the subjects in Group-3. The subject No.l only showed a comparitively large magnitude, the other four subjects showed less magnitude.

Zachariah's(1980) study has indicated that greater magnitude of reflex is an indicator of susceptibility to NIHL. Her study has been further supported by Jagadish (1982). In the present study it was attempted to find whether the subjects who exbibit greater magnitude of reflex would show a change in the magnitude of reflex after the ear is continuously stimulated. It was found that only one subjects demonstrated the expected relation.

Since the size of the sample tested in the present study is small, it is difficult to draw a conclusion regarding the relationship between greater magnitude of reflex and a change in the magnitude of reflex after continuous auditory stimulation.

From the Tables-1, 2, 3 it is clear that the majority of the subjects show a change in the magnitude of reflex after the ear if continuously stimulated using 2 KHz tone at 100 dBHL for one minute. Hence, 2KHz tone at 100 dBHL for 1 minute continuous exposure, appears to reflect the individual differences more effectively than the other stimulus parameters which have been used in the present study.

Table-1: Showing the magnitude of averaged reflex threshold (in cm) before ana after continuous stimulation using 1KHz tone at 100 dBHL for 1 minute.

Subjects	Before stimulation	After stimulation	Difference in cm.
1	0.5	0.5	-
2	2.3	1.8	0.5
3	0.8	0.8	-
4	0.4	0.4	-
5	0.6	0.2	0.4
6	0.6	0.2	0.4
7	0.8	0.7	0.1

Table-2: reflex threshold before and after continuous stimulation of a 2KHz tone of 100 dBHL for 1 minute (in cm).

Subjects	Before Stimulation	After Stimulation	Difference in cm.
1	1.7	1.7	-
2	1.9	1.3	0.6
3	1.8	1.5	0.3
4	1.6	1,2	0.4
5	1.0	0.3	0.2

Table-3: Showing the magnitude of averaged reflex threshold (in cm) before and after continuous stimulation by a 1KHz of 100 dBHL for 1 minute.

Subject	Before Stimulation	After Stimulation	Difference in cm.
1	1.8	1.6	0.2
2	1.1	0.9	0.2
3	1.0	1.0	-
4	1.5	1.5	-
5	1.3	1.3	-

Table-4; Showing the magnitude of reflex 10 dBSL - Threshold.

Subjects	500Hz	1KHz	2KHz	Average
1	2.0	1.5	1.0	1.5
2	2.5	3.0	4.0	3.2
3	3.0	4.5	5.0	4.2
4	4.5	5.0	5.5	5.0
5	2.5	1.5	2.1	4.0
6	4.0	2.5	4.0	3.5
7	1.5	3.5	4.0	3.0

Table-5: Showing the magnitude of reflex 10 dBSL - Threshold

Subject	500 Hz	1KHz	2KHz	Average
1	5.0	5.5	5.5	5.3
2	5.5	1.0	4.5	3.7
3	2.5	2.5	1.5	2.1
4	5.0	3.5	5.0	4.5
5	1.0	1.0	1.0	1.0

Table-6: Showing the magnitude of reflex 10 dBSL - Threshold

Subjects	500 Hz	1KHz	2KHz	Average
1	2.0	2.5	4.5	3.0
2	2.0	2.5	3.5	2.7
3	2.0	2.0	2.0	2.0
4	2.0	1.5	1.5	1.6
5	1.5	2.0	1.5	1.7

SUMMARY AND CONCLUSIONS

Continuous exposure to noise has many auditory and non-auditory effects on man. The auditory effect is a permanent hearing loss. But there are individual differences in the effect of noise or hearing.Research has shown that there are 'tough' ears and 'tender' ears. That is there are ears which are susceptible to noise induced hearing loss and some ears which are not susceptible to NIHL.

It is,therefore necessary to identify individuals who are susceptible to noise induced hearing loss, and protect them from the noise in their environment. To do this* we should have a test or a test battery which will give an index of susceptibility.

Most tests use the rationale that TTS is a predictor of susceptibility to NIHL. These tests assume that subjects who exhibit more TTS may be considered susceptible and those subjects who exhibit less TTS for the same stimulus are not susceptible. (Ward, 1967, Harris, 1967).

Grim and Bess (1973) gave the test of threshold of octave masking (TOM) as a test for susceptibility. Humes (1977) suggested the use of a test battery to predict susceptibility. It consisted of the followingttests.

1) The aural overload test.
2) The threshold of octave masking test.
3) The critical intensity (modified) procedure.
4) Word discrimination score in noise.

Many researchers have reported the effect of acoustic reflex on TTS (Borg, 1968, Brashner, 1969, Coles, 1969). This relation exists because the acoustic reflex attenuates low frequency sounds. As TTS depends on the intensity reaching the cochlea, the attenuation of the intensity due to the acoustic reflex will reduce TTS.

A relation between the acoustic reflex and susceptibility to NIHL also exists (Johansson et al., 1961, Miyakita et al., 1978).

Zachariah (1980) has found that subjects who have (1) low acoustic reflex and (2) large magnitude of reflex are susceptible to NIHL.

Kamakshi (1980) Concluded from her study that fatigability of reflex is related to TTS. Thus, another predictor of susceptibility is fatigability ofreflex. This is in agreement with Nilason et al., (1980) study.

Jagadish (1982) studied the relation between TOM and acoustic reflex threshold. He opines that there is a positive correlation between ART and TOM (which is frequency dependent). Further, the subjects showing low ART and low TOM (i.e. susceptible individuals) yield large magnitude of reflex.

The present study was undertaken to find out :

1) If subjects who exhibit a change in the magnitude of averaged reflex after continuous auditory stimulation be considered susceptible to noise induced hearing loss.
2) Does the amplitude (magnitude) of averaged reflex vary with the number of presentations of the stimulus before the ear of the stimulated.
3) Does the amplitude of averaged reflex vary with the number of presentations of the stimulus after the ear is continuously stimulated with an auditory stimulus?
4) What is the minimum duration of the continuous auditory signal, which brings about a change in the magnitude of the averaged reflex?
5) What are the physical parameters of the continuous auditory stimulus (such as frequency and intensity) which produce a change in the magnitude of averaged reflex?
6) Are there individual differences in the effect of continuous auditory stimulation on the magnitude of the averaged reflex?

The study was carried out in 2 experiments.

Experiment-I:

The effect of continuous auditory stimulation on the averaged refuse threshold.

The subjects were divided into 3 groups, each group exposed to continuous stimulus of different physical parameters. Group-1 consisted of 7 subjects, Group-11 and III consisted of 5 subjects each.

Subjects were 16 adult normals with no otologic and hearing problems. They were tested in a sound treated room. The averaged acoustic reflex was measured using the Madsen ZO-174 Immittance audiometer. This instrument has a special feature of giving averaged reflex.

Procedure: The right ear of the subject was selected as the probe ear. Only instruction given was - "Please be seated still and do not swallow".

Next, the 10 averaged reflex was recorded for the frequency 1KHz at ART. The reflex magnitude was measured in cm. The ear was then exposed to a continuous stimulus of 1KHz at 100 dBHL for 1 minute. Following which 10 averaged reflexes were once again recorded and magnitude measured. The Readings were tabulated and the difference between the two measurements was also tabulated.

In a similar manner the difference in magnitude of averaged reflex was measured after continuous stimulation for the Group-2 and 3. The stimulus parameters used were 1KHz tone of 100 dBHL far 2 minutes duration; and a 2KHz tone of 100 dBHL for 1 minute duration.

Experiment-II:

To measure the magnitude of acoustic reflex at reflex theshold and 10 dBSL (ref: ART) using Madsen (Electronics) Impedance Audiometer.

The same subjects of Experiment-1 were tested for the magnitude of reflex.

They were tested after a minimum interval of one day.

Procedure: The subjects were seated in a first room and given the instruction "Please be seated still and do not swallow".

The right ear was the probe ear and the left ear was the phone ear. After ensuring an air tight seal the following steps were followed:

1) The middle ear pressure was determined and keeping this presence contralateral reflex measurements were carried out.
2) The frequency 500Hz was selected and reflex threshold was determined.
3) The magnitude of deflection in the balance meter was noted.
4) The intensity was raised to 10 dBSL (ref. ART) and the magnitude of deflection was noted down. The difference between the two magnitudes was tabulated.
5) Similarly the magnitude of reflex at 10 dBSL was measured for 1KHz and 2KHz. The averaged magnitude was tabulated.

The following conclusions can be drawn:

1) The 10 subjects who exhibit a change in the magnitude of averaged reflex after continuous auditory stimulation do not show a large magnitude of reflex and hence the relationship between greater magnitude of reflex and reduction in averaged magnitude of reflex after continuous auditory stimulation is not established. However, as the size of the sample is small, a definite conclusion awaits further studies.

2) The amplitude of the averaged reflex does not vary with the number of presentation of the stimuli before the ear is stimulated.

3) But there Is a notable change in an amplitude of averaged reflex with the number of presentations of the stimulus after the ear is continuously stimulated with an auditory stimulus.

4) One minute was found to be the minimum duration of the continuous auditory signal, which brings about a change in the magnitude of averaged reflex.

5) A tone of 2KHz at 100 dBHL was found to produce a change in magnitude of averaged reflex as 80% of the subjects showed a change.

6) There are individual differences in the effect of continuous auditory stimulation on the magnitude of the averaged reflex.

Limitations:

1) The study was carried out on a very small population.
2) The physical parameters of the stimuli;used as the continuous auditory stimulus, were limited.

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