RACIAL DIFFERENCE AND T.T.S.

Reg. No. 8711

USHA RANI P. N

AN IDEPENDENT PROJECT SUBMITTED AS PART PULFILMENT FOR FIRST YEAR M.Sc. (SPEECH AND HEARING) TO THE UNIVERSITY OF MYSORE.

MAY 1988

ALL INDIA INSTITUTE OF SPEECH AND HEARING: MYSORE-6.

LOVING APPA AND AMMA

SWEET LIL CHINGA AND RAVI.

CERTIFICATE

This is to certify that the Independent Project entitied: “Racial Difference and TTS” is the bonafide work done in pat fulfillment for First year M.Sc. (Speech and Hearing) of the student with Reg. No. 8711.

Dr.N. Rathna,

Director,
All India Institute of
Speech and Hearing,
Mysore – 570006.

CERTIFICATE

This is to certify that the Independent Project entitied: Racial Difference and TTS has been conducted and prepared under my supervision and guidance.

Dr. M.N.Vyasamurthy

GUIDE

DECLARATION

This Independent Project entitled: "Racial Difference and TTS" is the result of my own study, undertaken 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

May 1988

Register No. 8711.

ACKNOWLEDGEMENTS

I am Greatly indebted to Dr. M.N.Vyasamurthy, Department of Audiology, AIISH, Mysore, for the patient guidance rendered by him through out this project.

I sincerely thank Dr. M.N. Zeelan, Ex-Director, AIISH, Mysore, for permitting me to take up this project and Dr.N.Rathn a , Director, AIISH, Mysore, for letting me complete this project.

I am thankful to Dr. S.Nikam, Prof. and HOD, Audiology Department, AIISH, Mysore, for permitting me to work on this project.

I am extremely thankful to Ms.Malini, M.S.Lecturer in Audiology, AIISH, Mysore, for all the help she extended at every step of this project, and Ms. Elizabeth, R.G., for her timely help.

I am extremely grateful to Mr. Bhoo Deepak and Mr. Charles Lwanda for their kind help in getting the international students for my subjects.

I thank all mys subjects, who ungrudgingly lent their ‘ears’ for this study.

I would not be out of place to express my grateful thanks to Suju, Jug and all there others who helped in various ways for the project.

I thank “Ruji” akka for typing out the project so neatly and in time.

TABELE OF CONTENTS

Chapter

--

INTRODUCTION

Noise, in the human world, seems to have pervaded every inch of space, occupying almost every moment of a person’s life.

‘Noise’ is defined as a random sound composed of different frequencies, not harmonically related. It is an erratic, intermittent, or statistically random oscillation, unwanted sound, within a useful frequency bands the bad being the one that carries the intelligibility of speech (Webster, 1969).

Noise has been known to have deleterious effects on the hearing sensitivity and hence is regarded as a special type of air pollution. The problem of noise has grown to extents where its control has come under the Federal Jurisdictions (Ward, 1969).

Some of the basic effects of noise on man are observed to be on the psychological system, non-auditorysystem and the auditory system. Some of the non-auditory effects are that of the physiological changes seen in cardio vascular, glandular and respiratory functions. Psychological functions like attentions concentration, attitudes, motivation etc.

are also observed to be affected (Cohen, 1969). However, the auditory functions which are affected by noise aer of greater interest to us and hence shall be discussed in detail.

The fact that excessive noise exposure causes hearing loss, has been established ever since the Bronze Age (Hinchcliffe, 1967). However, occupational hearing loss, especially noise induced hearing loss, is basically a direct consequence of the first and second Industrial Revolutions. Thus, work in this field dates back to a century (1986) (Alberti, 1979), while significant research on the effects of noise on man’s auditory behaviour started during the second world war.

The most common way of describing the effect of noise exposures on a person, is by noting its effect on his auditory thresholds. Ideally, the auditory thresholds are established prior to and following the exposure.

Post-exposure effects disappearing within a second are termed as “Residual Masking” (Munson and Gardner, 1950).

Those requiring upto a minute for complete recovery are termed as ‘ adaptation’. Those which require longer recovery times are said to represent ‘auditory fatigue’.

Auditory fatigue refers to the reduced sensitivity in the hearing sensation, following exposure to any stimulus of significant duration. Reduction in sensitivity is found in all sensory systems such as olfaction, gestation, vision etc. In all these cases, there is a reduction in sensitivity which is temporary, unless, the stimulation exceeds the critical limits of intensity and duration.

Some changes occur during the presentation of the stimulus, while some are seen after the termination of the stimulus (Eg. shift in auditory threshold). These effects are seen much less in the senses of olfaction, gestation and vision (Moore, 1977) than in audition.

The study of temporary changes in auditory perception caused by acoustic stimulation has a recent beginning, since the past 120 years only (Ward, 1973). The phenomenon of temporary auditory perception changes due to acoustic stimulation was discovered by Victor Urbantschitsch, in 1881.

The other types of auditory sensitivity decreases usually referred to are “auditory adaptation”, ‘auditory fatigue’, ‘acoustic trauma’, ‘temporary threshold shift’ (hereafter referred to as TTS)etc.

Some investigators use all these terms interchangeably except ‘acoustic trauma’, while others discriminate among them (Ward, 1965). Quite a few researchers differentiate between auditory fatigue and adaptation.

Hood (1950, 1972) defines ‘auditory fatigue’ as ‘a result of application of a stimulus which is usually considerably in excess of that required to sustain the normal physiological response of the receptor, and usually measured after the stimulus is removed’.

Adaptation, on the other hand, is defined as a special case of fatigue (Harris and Rawnsley, 1953).

The changes in auditory system could be due to other factors. apart from noise. Some of them are mentioned below

- Threshold changes due to ageing, which is refereed to as ‘presbyacusis’.

- threshold changes due to mumps, blows on the head, exposure to industrial toxins etc., which may affect the sensory mechanisms are termed as ‘nosoacusis’ (Greek: nosos – disease).

- Permanent threshold shifts produced by noises of everyday living are termed as ‘sociacusis’.

thus, noise induced hearing loss could be due to so many factors, that only noise exposure data as a cause is difficult to arrive at. so, in the absence of data on permanent threshold shift, we attempt to derive empirical conclusions from data on TTS.

The most common index for auditory fatigue is the temporary threshold shift (TTS), which by itself says that the shift is temporary and hence the hearing thresholds recover to the original threshold values over time.

TTS is the most studied after effect of auditory stimulation (Babighian et al. 1975). TTS is often used to predict noise induced hearing loss (NIHL) and the various susceptibility index of the individuals to NIHL.

Several factors are seen to decide the amount of TTS produced in an individual. Based on the TTS index, various Damage Risk Criteria have been proposed in the hearing conservation programs. One of the factors which could affect TTS could be the Race differences.

Till now, quite a few studies have shown a definite relationship between the hearing thresholds and racial differences. There are also evidences to show the effect of melanin pigmentation in the iris (eye color) and the TTS produced. However, there appear to be no investigations where the racial difference has been studied affecting TTS.

The present study was taken up to this end, to study any possible effects of the race differences between the Indian and the Negroid races on the TTS produced.

Statement of the problem :

The present study was aimed at finding out if there is any difference in the TTS measured between the Indian and the Negroid race, for a monaural stimulation at equal intensity levels and for equal duration of exposure.

Hypothesis:

"There is no significant difference between the subjects of Indian and the Negroid races in terms of the TTS".

Definition of the terms used :

TTS – Elevation in the threshold which recovers gradually following a noise exposure.

TTS_1 – Temporary threshold shift measured one minute after the cessation of the fatiguing stimulus.

TTS_2 – Temporary threshold shift measured two minutes after the cessation of the fatiguing stimulus.

Fatiguing stimulus: The acoustic stimulus used to produce auditory shift in the threshold.

Fatiguing frequency: The frequency at which the ear was exposed continuously to produce the fatigue.

Test frequency: The frequency at which the thresholds were determined after the ear was exposed to fatiguing stimulus.

--

REVIEW OF LITERATURE

The review shall be discussed and covered under three topics:

1. General information on TTS.
2. Iris pigmentation and TTS.
3. Racial differences in hearing threshold measurements.

1. General information on TTS:

Noise seems to have a deleterious effect on the hearing sensitivity of man. One of the measurements of susceptibility to noise is TTS.

Definition of TTS – Ward (1963) stated that "auditory fatigue is a time-linked process which grown with duration of exposure (majority of the times) and disappears as a function of time since exposure".

Corso (1967) defined TTS as the difference in the threshold of audibility measured before and after an individual has been exposed to sounds with known physical characteristics.

Humes and Bess (1978) – TTS refers to the transitory changes in hearing sensitivity induced by a fatiguing stimulus.

Types of TTS:

Ward (1973) described several types of TTS, depending upon the recovery pattern over time.

a) Ultra short term TTS or residual masking where, the recovery time is about one second.

b) Short-term TTS (low level adaptation): Recovery time is less than one minute.

c) Sensitization or facilitation: recovery time is about one minute.

d) Ordinary TTS (physiological fatigue): recovery time is greater than one minute and less than sixteen hours.

e) Long lasting TTS (pathological fatigue): where the recovery takes longer than 16 hours.

TTS which persist for more than two minutes are dependent on the level, duration and temporal patterns of the noise exposure. Those shifts which disappear within a second, depend on the level of the noise and are independent of the duration. Shifts which persist for about one minute, are to some extent independent of th3e level of the fatiguing stimulus (Ward, 1969).

Five major factors which influence the size of TTS are:

1. The time between the cessation of the fatiguing stimulus

and the post-exposure threshold determination.

2. The intensity of the fatiguing stimulus.

3. The duration of the fatiguing stimulus.

4. The frequency of the fatiguing stimulus.

5. The frequency of the test stimulus.

Growth of TTS:

General TTS increases with the duration of exposure upto some specific duration, after which it remains constant for a long period of time. The level of TTS reached and maintained after a certain duration of exposure is called the asymptotic threshold shifts (ATS),which is thought to reflect a balance between the fatiguing and recovery process in the cochlea.

In humans, it has been shown that this kind of plateau is reached after about 24 to 48 hours of continuous exposure (Melnick and Maves, 1974; Mills et al. 1979; Stephensen et al. 1979).

The growth of TTS is affected by many sound parameters such as duration, intensity levels, repetition rate, acoustic spectrum, etc. Growth is usually linear with the logarithm of time (Ward, 1963).

Both growth and recovery of TTS are an exponential process (Botsford, 1968; Keeler, 1968).

Recovery of TTS:

Recovery is also linear with logarithm of time, Recovery is faster at the initial stages, later slackening to a very slow pace (Ward, 1963).

Recovery cannot be measured till the ‘zero’ level, since, the relationship with time is of a logarithmic type. hence, for practical purposes, the recovery is taken to be complete once the pre-exposure thresholds are reached.

Longer the recovery time, smaller the TTS. But usually, a recovery from large TTS immediately following exposure is often followed by a ‘bounce’, particularly at high frequencies.

Sometimes the initial recovery process may actually overshoot the original threshold level, resulting in a temporary sensitization (Hughes and Rosenblith, 1957).

This diphasic nature of the recovery may be due to two processes – short lived recovery process which may correspond to the neural activity (R_2)and a longer recovery process corresponding to the hair cell and metabolic changes (R_1) (Moore, 1982).

The rate of recovery, from TTS Caused by hearing aid use in 4 children with sensorineural deafness was three to four dB, for atleast four hours after the cessation of aid use (Macrae, 1968).

Three types of recovery in addition to the logarithmic recovery are described:

a) Diphasie

b) Plateau

c) Rebound.

These were studied after an impulse noise induced TTS (Luz, 1971).

There are quite a few factors which are seen to affect TTS. They are discussed under the following topics:

I. Stimulus related factors

II. Subject related factors

III. Miscellaneous factors.

I. Stimulus related factors:

1. Intensity:

Generally, the growth of TTS is linear, more so, when measured after two minutes of exposure (TTS_2) (Ward, 1963).

For octave band noise, TTS is proportional to the amount by which the sound pressure level exceeds some base value (75dB) for octave band noise) (Ward, 1963).

2. Test frequency:

At low levels of stimulation, the maximum effect is produced at the stimulus frequency and less at the adjacent frequencies. At higher levels, effect is usually seen from half an octave to tow octaves above the simulating frequency (Van Dischoeck, 1948).

3. Exposure frequency:

The higher the frequency (upto 4 or 6KHz, at least), the more the TTS produced (Ward, 1963).

4. Duration of exposure:

TTS grows linearly with logarithm of time, except at lower frequencies, due to the action of the middle ear muscle reflexes (selters, 1962).

5. Binaural vs. monaural stimulation:

TTS is sen to be greater for monaural than binaural stimulation (Melnick, 1969; Guiot, 1969).

6. Temporal pattern:

Waveform of the stimulus (Phase spectrum) has a positive effect on the $TTS_{15\ min}$. (Buck et al. 1984)

7. Impulse Duration :

TTS using impulses of 34, 58, 72 or 96 /u seconds in duration, spaced one second apart at 168dB was studied. The correlation of number of impulses required to produce a 30dB TTS was highest when durations were similar (loeb et al. 1968).

8. Noise and TTS:

Threshold shifts in man are dependent on the physical parameters of the noise, which the ear is exposed to. High frequency noise components cause much greater threshold shifts than frequency noise components cause much greater threshold shifts than low frequency sounds, maximum being centred around 3000Hz.

Critical bands of one octave width are the most effective stimuli to produce maximum TTS (Weissing et al. 1968).

II. Subject related factors:

1. Sex difference:

No significant sex difference I noted by many studies(Zakaria, 1980; Petiot and Parrot, 1984; Shreemati, 1981; Nigam, 1987).

2. Age difference:

There is no significant age difference in TTS (Ward, 1963).

3. **Ear difference**:

Significant ear differences are noted by a few researchers (Glorig and Rogers, 1965; ward, 1967; Jerger, 1970), while other studies find no difference between the two ears for TTS (Waldron, and Mcnee, 1963; Bishnoi, 1975; Shreemathi, 1981).

4. **Central factors**:

Effects of differing states of attention on the acoustic reflex activity and TTS were studied and no positive differences were found.

Hence central factor probably an artifact of the type of task performance of the listener (Durrant and shallop, 1969).

5. **Articulation and phonation**:

TTS from exposure accompanied by humming is significantly less than TTS from exposure without any supplementary activity. TTS while reading aloud during exposure was less when compared with no reading during exposure.

Repeated turning of the head (non-vocal activity) resulted in less TTS than when no activity during exposure (Bengnerek, 1972).

6. Smoking and TTS:

Smokers evidence less TTS than non-smokers, when exposed to loud noise.

Non-somkers evidence greater TTS in the hot testing condition than in the cold conditions.

Smokers show no difference in TTS when tested in hot and cold temperature conditions (Dengerink, et al. 1978).

7. Eye color and TTS:

There is a positive effect of eye color on TTS (Hood,poole and Freedman, 1976). This particular topic shall be discussed in detail later in the chapter.

III. Miscellaneous factors:

1. Interactive effects:

The course of fatigue process and recovery process at one area of the basilar membrane is relatively independent of the conditions existing at the other areas of the membrane, during two different tones producing TTS consecutively (Ward, 1961).

2. Resting threshold:

TTS is inversely proportional to the hearing level i.e., the higher the hearing thresholds, the lower the

TTS Produced (Ward, 1963). i.e. subjects with conductive loss show lower shifts due to the loss of energy in conduction and in the sensorineural hearing loss case, the number of hair cells left undamaged are themselves less and hence lower fatique.

3. Latent and Residual effects:

Repeated, subsequent exposures do not enhance the magnitude of TTS (Ward, 1960). Increments in TTS with every subsequent exposure, after the previous exposure TTS reaches ‘zero’ shifts, show the presence of residual effects (Harris, 1955).

4. Vibration:

Vibration along with noise exposure seem to produce more TTS than noise alone (Morita, 1958).

5. Vitamin ‘A’ :

Excessive vitamin ‘A’ administered to subjects with normal diet shows no effect on TTS and its recovery, while it might have some effect, in vitamin ‘A’ deficient subjects (Ward, 1968).

6. <u>Oxygen</u>:

Excess of oxygen has no effect on TTS, while adequate oxygen content is necessary for normal functioning. (Hirsh, and Ward, 1952).

7. <u>Salt</u>:

Cook (1952) speculated an increase in TTS with excessive use of ordinary salt, No experimental data is yet available (Ward, 1963).

8. <u>Drugs</u>:

Myorelaxins produce more TTS. This is because, the middle ear muscles get relaxed and hence more energy reaches the cochlea during exposure (Lehnhardt, 1959).

9. <u>Temperature</u>:

Cold temperature in the environment produces less TTS. This could be due to the increased peripheral vasoconstriction at low temperatures. (Dengerink, et al. 1978).

10. <u>Pop music and TTS</u>:

TTS is less pronounced, among the pop-musician when compared to the listeners of the pop-music (Axelesson et al. 1978).

11. Acoustic reflex and TTS:

When acoustic reflex is present, the pure tone exposure produces 10dB more TTS_2 than the noise exposure. When acoustic reflex was not present, the pure tone and noise exposure both produce similar TTS_2. (Mills and Lilly, 1971).

2. Iris pigmentation and TTS:

Literature reports that subjects with highly pigmented irises (brown)experience significantly less TTS than subjects with less pigmented irises (blue), and that those with green-gray pigmentation display intermediate amounts of TTS.

Bonaccorsi (1965) states a high correlation between the melanin content in the stria-vascularis and that found in the pigmentation of the iris. We observed that the stria vascularis was without pigment when the iris was blue, and that the concentration of melanin in stria vascularis increased with increased pigmentation of the iris.

Preibam (1908) found that homolateral hearing loss may occur on the side of the depigmented iris persons with two differently colored eyes.

Turaine (1955) reported that albino subjects often display a loss of hearing sensitivity.

Bonaccorsi and Galiato (1965) report that the auditory deficit in the guinea pigs from industrial noise was inversely proportional to the pigment in the stria vascularis.

Tota and Bocci (1967) tested blue eyed subjects on one end of a graded scale of eye coloring showing appreciably greater fatigue than brown-eyed subjects at the other end of the scale. They conducted the study for an exposure of 100Hz at 110dB SPL for three minutes. They attribute their TTS Differences across eye color to the protective effects of melanin in the stria vascularis.

Kood, Poole and Freedman (1976) study confirms the relationship between the melanin content and TTS in a positive way.

New evidences show that for stimulus intensities below 110dB (NTL ke ISO, 1964), melanin content of the iris exerts it influence predominantly upon auditory adaptation, while fatigue effects only become apparent at intensities above this level.

karlovich (1975) on the other hand, does not support the hypothesis that individuals with highly

Pigmented irises (brown eyed) are more resistant to auditory fatique than those with less pigmentation of the iris (blue eyed).

This disagreement has been argued by Hood, Poole and freedman (1976) and is said to be true perhaps because Karlovich measured auditory fatigue and not auditory adaptation as was the case with Tota and Bocci study. This was due to the difference in methodology followed by Karlovich, where he used a fatiguing stimulus of 1000Hz at 120dB SPL for 3 minutes.

Physiology of melanin pigmentation : Bonaccorsi(1963), found topographic correlations between the cells of the melanogenetic system and the vascular plexi, which are responsible for the production, amongst other humors, of endolymph and Pellymph and upon this basis, attributes a function to melanin, described as being ‘phylogenetically angioprotective’.

Although the biological role of melanin in the cochlea remains largely a matter of speculation, there exists a sufficiently large body of evidence to suggest the importance of its presence.

La Ferriere et al. (1975), say that the studies on melanin are more than a passing interest that the distribution of melanocytes is largely confined to the well vascularized regions of the labyrinth of apparent secretary and metabolic importance.

Lindquist (1973) demonstrated that melanin granules had a high affinity for various ototoxic drugs in vitro. In addition, a number of authors have commented upon the association of sensorineural deafness and pigmentary disorders, the best known example being that of Waardenberg’s syndrome (Fisch, 1959).

Melanin acts as a ‘sink’ for free radicals. The existence of such free radicals in the cochlea at high, stimulus intensities may be presumed, though they have yet to be established, If this were the case, then absorption by melanin could hasten the process of recovery (Commoner, et al. 1954).

3. Racial differences in hearing threshold measurements:

Quite a few studies have been reported in the literature about the possible differences in the hearing thresholds of individuals belonging to different races.

Auditory sensitivity differences were analyzed among 169 blacks and 524 white subjects. (Bunch and Raiford, 1931) They observed no difference that was significant between the black females and white females (matched for age between 20 and 50 years). However, black males showed better sensitivity than white males for frequencies above 2048 Hz in every age group.

Rosen et al (1962) studied the Mabaans (all black race) and compared their hearing sensitivity with the other population data (White) and found that the formar exhibited better high frequency hearing with age.

Shepherd et al. (1964). compared all black population with predominantly white population and found a difference between the two, in favour of black population. They observed the difference to be genetic origin. They hypothesized that the hearing difference between the races as seen by Rosen et al might be due to “actual in born differences between the biophysical systems” rather than to cultural or environmental factors.

They found that the white males and females have better hearing at 1-2KHz than their black counterparts.

Using Bekesy audiometry, at slow and fast speeds of pulsed and continuous tones, no significant difference between the black males and white males, while white females have lower thresholds than their black counterparts for only one stimulus type. These conflicting results were attributed to the possible socio-economic and cultural differences in sociacusic factors (Shepherd et al. 1964).

The thresholds for children show no consistent racial differences, while in adults, there is a consistently poorer hearing for whites at frequencies above 2000Hz (from the age of 30 years), especially among males (Post, 1964).

The National Health Survey Reports of 1960-62(U.S.A) for Race and sex differences, found that the black (males and females) had better than average thresholds for frequency 0.25 to 6KHz, when compared with their white counterparts.

The National Health Survey of 1966-70 (U.S.A)analyzed Race and Sex differences among youths and found that the white girls had better hearing sensitivity than the black girls at all the frequencies except at 6000Hz.

The white boys had good sensitivity to frequencies between 1-3KHz, when compared with the black boys.

Berger et al (1977) found that the whites had better hearing than the blacks across test frequencies 500-6000Hz with an average of 4dB difference between thresholds for the race groups.

Comparison between the average hearing threshold levels for the non-industrial noise exposed population of black populations to the white community showed the blacks to have more sensitive hearing (Royster et al. 1980).

Black longshoreman indicate better hearing at higher test frequencies than the whites (Karsai et al. 1972).

Lilley et al (1977) found racial differences in the average HTLs among the industrial noise exposed populations, wherein, the blacks showed consistently better hearing than the whites, with large differences (upto 15dB) at frequencies above 2000Hz. The authors noted that these findings could imply that blacks could be less susceptible to NIHL than whites.

Royster et al. (1980) studied large industrial noise exposed populations and found that the black females had the poorest sensitivity of hearing.

--

METHODOLOGY

Subjects:

All the twenty subjects were males, Ten were of Indian race and ten of the Negroid race.

Age range: Indian subjects ranged from 20 Years to 30 Years, with a mean age of 21.98 Years.

The Negroid subjects ranged from 25 Years to 35 years, with a mean age of 28.5 years.

The hearing sensitivity (air conduction thresholds) of all the subjects were within 20dBHL (ANSI, 1969), for frequencies 250Hz through 8000Hz.

Equipment:

A Madsen TBN-85 audiometer was used for testing. Stimuli were presented through TDH-39 earphones, housed in MX 41/AR ear cushions. The instrument was calibrated according to the BIS, 1983. specifications prior to the experiment. The calibration procedure undertaken is given in appendix-A.

listening checks were routinely conducted just before each testing session.

Test environment:

The experiment was conducted in a sound treated audiometric room, where the ambient noise levels were well below the proposed maximum allowable noise levels. Noise levels in the room are given in Appendix-B.

The test was conducted in a single room situation, with only two individuals (the tester and the subject) present during the test. Both the tester and the subject were seated comfortably, with the subject facing his back towards the audiometer and the tester. The test environment was comfortable in terms of humidity, temperature, lighting, etc.

Test Procedure:

Air condction thresholds for both the ears across the octave frequencies of 250Hz through 8000Hz were obtained using the Modified Hughson-Westlake procedure (Carhart and Jerger, 1959).

The ear with better pure tone average (PTA)was tested during the experiment. Only one ear was tested for each subject. If both ears had similar PTA, then the right ear was tested. Each subject was tested only once and it was ensured that they were not exposed to auditory fatigue or any other high level noise for a minimum of 24 hours. This was done so as to ensure complete recovery from any prior exposures.

Following the threshold determination, the subject was given a sample of the fatiguing stimulus for a very short duration (two seconds). Upon the approval of the subject to tolerate the loud tone for five minutes, he was instructed as follows:

"you will be hearing the loud tone for five minutes. After five minutes, I will stop giving the tone and will present softer tones for short duratrions. Raise your index finger and respond as before, whenever you hear the tones. Do you have any questions?".

Following the instructions, the subject was exposed to the fatiguing stimulus of 2000Hz for five continuous minutes at 100dB HL.

The threshold measurement was done only at 4000Hz oneminute and two minutes after the cessation of the fatiguing stimulus (TTS_1 & TTS_2 respectively). The TTS measurements were done only after one minute so as to avoid the 'Bounce Phenomenon' (Hirsh and Ward, 1952). The TTS effects were measured at 4000Hz since it is observed that the maximum TTS occurs half an octave to one octave above the fatiguing frequency (Ward, 1963).

The thresholds were recorded manually. The data obtained was analyzed using appropriate statistical procedures. The details of the results obtained are discussed in the following chapter.

RESULTS AND DISCUSSION

The data collected were analyzed so as to obtain the mean threshold shifts in the two groups. Standard deviation (S.D.) of the threshold shifts was computed to assess the variability. The results were also analyzed using the t-test for measuring the significance of difference between the mean threshold shifts in the two groups.

The values of the threshold shifts for the Indian and the Negroid subjects are given in the Tables 1a and 1b respectively. The tables indicate that the subjects in the Negroid group (Group-2) have lower threshold shifts than the subjects in the Indian race (Group-1).

Tables 2a and 2b give the mean and the standard deviation values TTS_1 and TTS_2 for both the groups. Figures 1 and 2 represent the shifts graphically. Though the mean values of the threshold shift show lower values for both TTS_1 and TTS_2 in the Negroid group, the difference was not significant statistically ($t=1.05$ for TTS_1 and $t=0.76$ for TTS_2).

Table 1a: TTS (TTS_1 and TTS_2) at 4KHz: Group-1 (Indian race)

Subjects	1	2	3	4	5	6	7	8	9	10
TTS_1	20	20	15	25	15	25	20	15	35	30
TTS_2	20	20	10	20	10	20	20	15	30	30

Table 1b: TTS (TTS_1 and TTS_2)at 4Khz Group-2 (Negroid race)

Subjects	1	2	3	4	5	6	7	8	9	10
TTS_1	25	30	30	20	5	15	20	15	15	10
TTS_2	15	30	30	20	5	15	15	15	15	10

Table 2a: Mean and S.D. of TTS_1 and TTS_2, Group-1 (Indian race)

	Mean	S.D.
TTS_1	22	6.4
TTS_2	19.5	6.5

Table 2a: Mean and S.D. of TTS_1 and TTS_2, Group 2 (Negroid race)

	Mean	S.D.
TTS_1	18.5	7.76
TTS_2	17.0	7.48

The results of the present study contrast with the findings of the studies done on Race differences for hearing thresholds. Some of the earlier studies of Bunch and Raiford (1931), Rosen et al. (1962); Shepherd et al. (1964); Post (1964) and Royster (1980) show significant differences between the whites and the blacks in the

Mean TTS, in Group I (Indian) and Group II (negroid) at 4KHz. (fatiguing stimulus is 2KHz tone at 100dBHL for 5 minutes).

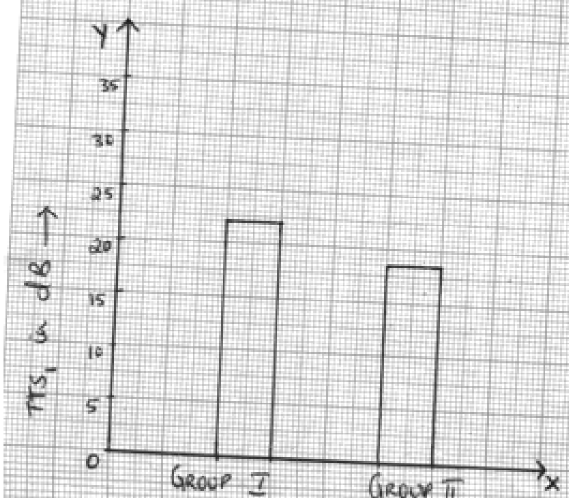

Fig. 1.

Mean TTS_2 of Group I and Group II (Indian & Negroid respectively) at 4KHz. (Fatiguing stimulus of 2 KHz at 100 dB HL for 5 minutes).

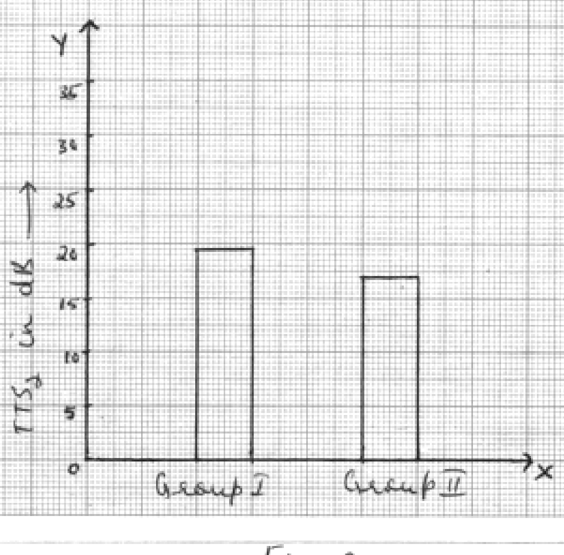

Fig. 2.

hearing thresholds. All the studies found poorer hearing thresholds, among whites than in the blacks. The results of this study however showed no significant difference between the Indian and the negroid races, for TTS.

The probable reason for the above findings could be the difference in the races studied upon. Also, the present study involved a supra-threshold measure, while the others were centred around threshold measures.

It is interesting to note that there areno differences in TTS between the 2 races presently studied, the terms of the melanin pigmentation of the skin inspite of the Negroid subjects having darker skin color (higher melanin content). This is in contrast with those studies which have found correlations among the iris color and the TTS.

Studies have shown that TTS produced is less among those with dark iris pigmentation than those with lighter shades of iris color, (Tota and Boci, 1967; Hood, Poole and Freedman, 1976). This fact has been attributed to the amount of melanin pigment present in the iris and the stria vascularis. The melanin pigment has been attributed with protective function of the hearing, when present in larger concentration.

However, there appears to be no established correlation between the amounts of melanin content in the skin and the stria vascularis, as between iris and stria vascularis. This would probably explain the contrary results obtained in this study.

Implications:

The percentage of an industrial population potentially compensable for hearing loss caused by on-the job noise exposure is strongly dependent on the Race and Sex characteristics of the population. The knowledge of the racial differences found in the hearing levels have a role to play in the hearing conservation programs, wherein the hearing level shifts of industrial employees show a great difference on a racial bais (Royster, 1980).

Since no differences are observed between the Indian and the Negroid races in terms of TTS as per the present study, it is possible to speculate on the applicability of common hearing conservation programs across the two races. However, further research has to be conducted on this line for further conclusions.

--

SUMMARY AND CONCLUSIONS

The study was aimed at investigating any relationship between the Indian and the Negroid race and TTS produced, to probe the effects of Race difference in TTS.

A madsen TBN-85 audiometer with TDH-39 earphones housed in MX-41/AR supra aural ear cushions, which was calibrated according to the BIS, (1983) was used for the experiment.

Twenty normal hearing male subjects, ten of Indian and ten of the Negroid race, served as subjects for the study. Mean age of the Indian subjects was 21.98 years with an age range of 20-30 years. The subjects of the Negroid race were in the age range of 20-35 years, with a mean age of 28.5 years.

TTS_1 and TTS_2 were measured for each individual at 4000Hz, after an exposure of five minutes to a pure tone fatiguing stimulus of 2000Hz, at 100dBHL. The data obtained was analyzed to obtain the central tendency measure (mean) andn the variability measure (standard deviation). Also, the t-values of the data were obtained by administering the t-test.

CONCLUSIONS:

1. No significant difference is seen between the two groups in terms of TTS_1 FOR A 2000Hz stimulation at 100dBHL for five minutes, presented monaurally, both at the 0.01 and 0.05 levels of significance (t=1.05).

2. No significant difference between the two groups noted for the TTS_2 Values of both the 0.01 and 0.05 levels of significance (t=0.76).

3. There is a greater amount of TTS among the Indian subjects in terms of the mean scores, in comparison with the Negroid subjects, though the difference is not significant statistically.

As the study indicates no difference in the TTS produced in terms of races, it would probably be possible to say that common hearing conservation programs be applicable for both the races. However, further studies on this line have to be conducted, in order to generalize this conclusion safely.

Suggestions for further research :

1. To study the race difference on larger samples of population.

2. To study the effects of various other races on TTS.

3. To study the race difference in female subjects.

4. To conduct similar studies with subjects of different age groups.
5. To conduct race difference studies on TTS among industrial workers and other professionals.
6. To study the race differences on TTS using stimuli of different frequency, intensity and duration.

--

BIBLIOGRAPHY

Alberti, P.W. (1979) "Noise and the ear", In J. Ballantyne and J.Groves (Editors) "Diseases of the Ear, Nose and Throat" (4th edition) Vol.2, "The ear", Butter worths, London (551-557).

Axelsson, A. and Lindgren, F. (1978) "Temporary threshold shift after exposure to pop music", Scand. Audiol.,7, (127-135).

Babighian, G. Moushegian, G. and Rupert, A.L. (1975) "Central auditory fatigue". Audiology, Vol.14, (72-83).

Benguerel, A.P. and McBay, H.D. (1972) "Changes in TTS Associated with humming and NOnvocal Activities", J.Acoust. Soc.Am., Vol.52, (1107-1114).

Benties, L.D., Eldredge, D.H., and Templer, J.W. (1972) "Temporary threshold shifts in chinchilla: Electrophysiological correlates", J.Acoust.Soc.Am., Vol.52, (1115-1123).

Botsford, J.H. (1971) "Theory of temporary threshold shift", J.Acoust.Soc.Am., Vol.49, (440-446).

Buck, K., Dancer, A., and Franke, R. (1984) "Effect of the temporal pattern of a given noise dose on TTS in Guinea pigs". J.Acoust.Soc.Am, Vol.76, (1090-1097).

Corso, J.F.,(1967) "The Experimental Paychology of Sensory Behaviour" New York, Holt, Rinehart and Winston Inc, (331-336).

Dengerink, H.A., Trueblood, G.W., and Dengerink, J.E.(1984) "Effects of smoking and environment temperature on temporary threshold shifts", Audiology, VOl.23 (401-410).

Durrant, J.D., and Shallop, J.K. (1961) "Effects of differing states of attention on acoustic reflex activity and temporary threshold shift", J.Acoust.Soc.Am., Vol.46 (907-913).

Elliot, N., and Winifred, R.F. (1970) "Fatigue and Adaptation", In J.V.Tobias (Editor), "Foundations of Modern Auditory Theory", Academic Press, New York.

* The original article has not been referred to.

Garrett, H.E., (1985) "Satistics in Psychology and Education" (Eleventh edition), Vakils, Feffer and Simons Ltd. Bombay (27, 49-50, 294, 461).

Green, D.S. (1978) "Pure tone air conduction testing", In J.Kats. "Handbook of clinical Audiology"(2nd edition), Williams and wilkins Company, Baltimore (98-103).

Guiot, J.M. (1969) "Temporary threshold shifts following pulsed monaural and alternate binaural exposure", J.Acoust.Soc.Am. Vol.46,(1449-1451).

Gunja, N. (1984) "Ear difference in temporary threshold shift for binaural stimulation", Independent Project, A.I.I.S.H. University of Mysore.

Hood, J.D. (1950) "Studies in auditory fatigue and adaptation", Acta Oto-Laryngol., Stockh, Suppl.92, (1-57)

Hood, J.D. Poole, J.P. and Freedman, L. (1976) "The influence of eye color upon temporary threshold shift", Audiology. Vol.15 (449-464).

Karlovich, R.S., (1975) "Comments on the relations between auditory fatigue and iris pigmentation", Audiology, Vol.14 (238-243).

Kryter, K.D.(1969) "Opening remarks" In W.D. Ward and J.E. Fricke (editors) "Proceedings of the conference Noise as a public Health Hazard", ASHA Reports 4, American Speech and Hearing Association, Washington, D.C. 1969 (37-39).

LaFerrire, K.A., Arenberg, I.K., Hawkings, J.E., and Johnson, L.G., (1974) "Melanocytes of the vestibular labyrinth and their relationship to the microvasculature", Ann.Otol.Rhinol.Lar.Vol.83, (658-694).

Loeb, M. and Fletcher, J.L. (1968) "Impulse duration and temporary threshold shift", J.Acoust.Soc.Am Vol.44 (1524-1528).

Luz, G.A., and Hodge, D.C. (1971), "Recovery from impulse noise induced temporary threshold shift in monkeys and man: A Descriptive Model", J.Acoust.Soc.Am., Vol.49,(1770-1777).

Macrae, J.H., (1968) “TTS and recovery from TTS after use of powerful Hearing aids”, J.Acoust.Soc.Am. Vol.43, (1445-1446).

Macrae, J.H., (1968) “Recovery from temporary threshold shift in children with sensorineural deafness”, J.Acoust.Soc.Am. Vol.44 (1451).

Malini, M.s, (1981) “Standardization of Nu Auditory Test No.6, on an English speaking Indian Population”, Master’s Dissertation A.I.I.S.H. University of Mysore.

Mills, J.H., and Lilly, D.J. (1971), “Temporary threshold shifts produced by pure tones and by noise in the absence o an acoustic reflex”, J.Acoust.Soc.Am. Vol.50, (1556-1558).

Moore, B.C.J. (1982) “An introduction to the psychology of hearing”, 2nd Edition, Academic Press, London (60-66).

Nielsen, D.W., Beuman, M.J., and Brandt, D.K. (1986) Changes in auditory threshold during and after long duration noise exposure: Species differences”, Pg. 281-284. In R.J.Salvi, D.Henderson, R.P.Hamernik, and V.Colletti (editors), “Basic and Applied Aspects of Noise Induced Hearing Loss”. NATO ASI Series, Series A: Life Sciences, Vol.111, Plenum Press, New York and London.

Newby, H.A., and Popelka, G.R., (1985), “Audiology” (5th edition), England cliffs, Prentice Hall Inc, New Jersey, (93-250).

Nigam, R., (1987) “Sex differences in auditory fatigue”, Independent Project, A.I.I.S.H. University of Mysore.

Petiot, J.c., and Parrot, J.E. (1984) “Effects of the ovarian and absolute thresholds, auditory fatigue and recovery from temporary threshold shifts at 4 and 6 KHz” Audiology , Vol.23 (581-598) As quoted by Sheela, K. (1987) “Ear difference in temporary threshold shift for monaural stimulation”, Independent Project, A.I.I.S.H., University of Mysore.

Royster, L.H., Royster, J.D., and Thomas, W.G. (1980) "Representative hearing levels by race and sex in North Caroline Industry", J.Acoust.Soc.Am. Vol.68, (551 - 566).

Sheela, K (1987) "Ear difference in temporary threshold shift for monaural stimulation", Independent Project, A.I.I.S.H., University of Mysore.

Sudhir Bhanu, (1986) "Temporary threshold shifts for Multiple frequencies", Independent Projects, A.I.I.S.H. University of Mysore.

Ward, W.D., (1963) "Auditory Fatigue and masking" in J.Jerger (Editor) "Modern developments in Audiology", New York, Academic Press (240-286).

Ward, W.D. (1965) "Psychoacoustics", In A. Glorig (editor)"Audiometry: Principales and Practices", Baltimore, The Williams and Wilkins Company (64-66).

Ward, W.D. (1969) "Effects of Noise on Hearing Thresholds" In.W.D.Ward, and J.E.Fricke (editors)"Proceedins of the conference 'noise as a Public Health Hazard",Washington, D.C.ASHA Report 4, The American speech Hearing Association, Washington.

Ward, W.D. (1973) "Adaption and Fatigue", In J.Jerger (editor) "Modern Developments in Audiology" 2nd Edition, New York, Academic Press, (301-339).

Ward, W.D. (1984) "Noise induced hearing loss" In J.L. Northern (Editor) "Hearing Disorders", 2nd edition, 1984, Little, Brown and Company Boston/Toronto (143-153).

Weissing, H. (1968) "Relation of threshold shift to noise in the human ear", J.Acoust.Soc.Am. Vol.44 (610-615).

Zakaria, A.e, (1980) " A Study of the relationship between the acoustic reflex threshold and temporary threshold shift", Master's Dissertation, A.I.I.S.H., Univeristy of Mysore.

--

APPENDIX A

CALIBRATION PRECEDURE

1. Pure tone Calibration

Calibration was checked for both frequency and intensity output of the pure tones generated by the audiometer (Madsen TBN-85) which was used in the study.

Calibration was checked prior to the study.

1.a) Intensity Calibration:

All intensity measurements were done when the audiometer output was set at 60dBHL,BIS, (1983).

The acoustic output of the audiometer was given through earphones (TDH-39, housed in MX-41/AR ear cushions) to a microphone, B&K type 4144, which was fit into a B&K artificial ear type 4152.

The signal produced was fed into a B&K sound level meter type 2209 with an filter set, B&K type 1613. The sound pressure level values at the corresponding frequencies were noted.

Whenever the difference between the observed SPL value and the expected value (BIS, 1983) was more than 3.dB, Internal calibration was done by adjusting the presets in the audiometer.

Thus the output levels of the audiometer wave well within 3dB with reference to the standards.

1.b) Frequency calibration:

The frequency of the pure tones were checked using a Digital Frequency Counter. For this, the electrical out put the audiometer was given.

The frequency observed on the frequency counter and that generated by the audiometer were compared.

The differences between the two readings never overshot a 3% (for 4000Hz and below) or 5% (4000Hz and above) level, and if they did, then the internal frequencies was calibrated. The generated frequency was never more than $\pm$ 3% of the specified frequency. Whenever the values exceeded this limit, the internal frequency calibration was taken up.

APPENDIX B

Noise levels in the test room were as follows:

Frequency in Hz.	Ambient noise level in dB SPL
125	30
250	18
500	<10
1000	<10
2000	<10
4000	<10
8000	<10

A B & K type 2209 SLM connected to a B&K Type 1613 octave filter set and a microphone B&k type 4144 were the instruments used for the measurement of ambient noise levels.