TO MY PARENTS

EAR DIFFERENCE IN TEMPORARY THRESHOLD SHIFT FOR BINAURAL STIMULATION

Register No. 8412

Nazneem Gunja

An independent project submitted as part fulfilment for
First Year M.Sc. (Speech and Hearing) to the
University of Mysore

MAY 1984

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

CERTIFICATE

This is to certify that the Independent project entitled:

" EAR DIFFERENCE IN TEMPORARY THRESHOLD SHIFT FOR BINAURAL STIMULATION ".

Is the bonafide work, done in part fulfilment for First Year M.Sc.,(Speech and Hearing) of the student with Register No.8412

Director
All India Institute of
Speech & Hearing
Mysore - 570006

CERTIFICATE

This is to certify that the Independent Project entitled:

"EAR DIFFERENCE IN TEMPORARY THRESHOLD SHIFT FOR BINAURAL STIMULATION"

has been prepared under my supervision and guidance.

GUIDE

DECLARATION

This Independent Project entitled: "EAR DIFFERENCE IN TEMPORARY THRESHOLD SHIFT FOR BINAURAL STIMULATION" is the result of my own study undertaken under the guidance of Dr. M.N.Vyasamurthy, Lecturer in Audiology, All India Institute of Speech and Hearing, Mysore and has not been submitted earlier at any University for any other Diploma or Degree.

Mysore REGISTER No.8412

April, 1984

ACKNOWLEDGEMENTS

I am extremely grateful to Dr. M.N.Vyasamurthy, Lecturer in Audiology, All India Institute of Speech and Hearing, Mysore, for the priceless guidance rendered by him at every step of this project.

I would like to sincerely thank Dr. Rathna, Director, All India Institute of Speech and Hearing, Mysore, and Dr.S.Nikam, Head of the Department of Audiology, All India Institute of Speech and Hearing, Mysore.

I am also grateful to Dr.Pusalkar, Head of the Department of Audiology and Speech Therapy, B.Y.L. Nair Hospital, Bombay, for permitting me to use the instrument and Mr. Jagadeesh, Professor, Audiology and Speech Therapy Department, B.Y.L.Nair Hospital, Bombay, for his advice and help.

The kind Co-operation of all the subjects and other staff and students (1983) Audiology and Speech therapy Department, B.Y.L. Nair Hospital, Bombay is appreciated and acknowledged.

Lastly, I would like to thank Ms. Rajalakshmi R Gopal, for typing out this project for me.

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INTRODUCTION

INTRODUCTION

Ward (1963) says 'auditory fatigue' is one of a number of terms used to describe a temporary change in threshold sensitivity following exposure to another auditory stimulus.

The most common index for auditory fatigue is the TTS which indicates any post stimulatory shift in auditory threshold that recovers over time.

Auditory fatigue is a time-linked process. It not only grows with duration of exposure, but also disappears, more or less swiftly, as a function of time since exposure.

Ruedi (1954} distinguishes between 'physiological fatigue' and 'Pathological fatigue'.

Post exposure threshold changes have been put into different categories on the basis of their persistance in time. Thus, though there are many processes, a neutral term 'TTS' is used to indicate any post stimulatory shift in threshold.

The production of TTS is dependent on many factors. If a steady pure tone is used, the frequency, intensity and duration are important. It is seen that if the fatiguer is intermittent or has time varying frequency characteristics, the TTS produced will be less than that produced by the same amount of energy in a steady exposure.

Many characteristics of the listener are apparently also important. There are large differences between individuals in the TTS produced by a given exposure.

Miscellaneous factors that affect TTS are interactive effects, resting threshold, latent and residual effects, vitamin A, oxygen, salt, vibration, drugs and level of consciousness, sex, age and experience, articulation, central factors and binaural versus monoaural TTS.

The psychoacoustic literature on TTS affords little information bearing directly on the question of whether there is any ear difference in TTS for binaural stimulation.

Several studies do however, consider the comparability of monoaural and binaural TTS exposures upon monotonically measured TTS. Hirsh (1958) reported little difference between monoaural and binaural exposures in the average ear. Ward (1965) found that binaural exposure produced less TTS than did monoaural and concluded that these differences resulted from rigorous contraction of the middle ear muscles during binaural stimulation. He did, however acknowledge the possibility of influences exerted through efferent connections.

TTS at low frequency following monoaural and binaural exposure have revealed that, TTS following binaural exposures is less than the TTS following monoaural exposures. (Hirsh, 1958; Ward, 1965; Karlovich et al 1972; Karlovich et al 1974).

Ear difference in auditory fatigue has been reported (Glorig and Rogers, 1965; Ward, 1967; Jerger, 1970) Weiler, 1974).

Shreemathi (1981) in her study, found that there is no difference in TTS between the left and right ear for the control condition as well as for the experimental condition. Bishnoi (1975) reported similar results regarding ear difference in TTS and its recovery.

The issue of central influences on auditory fatigue was raised when Wernick and Tobias (1963) reported that mental activity in the form of mental arithmetic during a pure tone exposure resulted in a more auditory fatigue than the same exposure during 'reverric'.

STATEMENT OF THE PROBLEM:

The present study is aimed at studying if there is any ear difference in temporary threshold shift produced by binaural stimulation at equal intensity levels and for equal duration of exposure.

HYPOTHESIS:

There is no significant ear difference in TTS produced by binaural stimulation at equal intensity levels and for equal duration of exposure.

IMPLICATIONS OF THE STUDY:

1. It provides information regarding TTS for binaural stimulation.
2. It provides information about TTS at 4 KHz and TTS at 8 KHz for binaural stimulation.
3. It provides information regarding presence or absence of ear difference in TTS for binaural stimulation.
4. The information regarding the ear difference in TTS for binaural stimulation may throw light on the efferent mechanisms in hearing.

LIMITATIONS OF THE STUDY:

1. The fatiguing frequencies used were limited to the higher frequencies, 2 KHz and 4 KHz only.

2. Only a small population was tested.

3. The age range was limited.

DEFINITIONS OF THE TERMS USED:

Temporary threshold shift (TTS): Refers to an elevation in the threshold of hearing which recovers gradually following the noise exposure.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

In 1882, Oscar Wilde Wrote "America is the noisiest country that ever existed. One is walked up in the morning not by the singing of the nightingale but by the steel workers. It is surprising that the sound practical sense of the Americans does not reduce this intolerable noise. All art is based on exclusive and delicate sensibilities and such continual turmoil must ultimately be destructive to the musical facilities".

Whoever has ridden in the pilot's compartment of an airplane, or worked in the proverbial boiler factory, or indulged in much shooting can recall how his ears range for hours afterwards and voices sounded muffled and indistinct. Loud sounds could be heard as well as ever, but he was temporarily hard of hearing. After a few hours, or by the day following atleast, his hearing had recovered. Recovery from this hearing loss is usually so complete that the hearing loss may probably be considered a fatigue rather than an injury.

"For a long time, the problem of auditory fatigue has been mixed with uncertainity and controversy". Thus, Wever began his section of auditory fatigue in 1949. It was apparently still true two years. later, when De Mari (1951) used the same sentence to introduce a discussion of the subject. And, alas, the ensuing 30 years have done little to dispel the controversy and reslation, although some progress has been made in reducing uncertainity.

Auditory fatigue is one of a number of terms used to describe a temporary change (usually but not always, a decrease) in threshold sensitivity following exposure to another auditory stimulus. It may be called a 'line dead' situation. Here the appropriateneural elements are either temporarily incapable of being fired, or atleast are refractory .

TTS or post stimulatory fatigue has generated a number of interesting investigations both experimental and clinical and perhaps been the most studied after effect of auditory stimulation.

BINAURAL AND MONOAURAL STIMULATION IN TTS:

Hirsch (1958) studied monoaural TTS following monoaural and binaural exposures under 3 experimental conditions to ascertain whether or not TTS depends upon whether one ear or both ears were exposed to sound. The results showed that "The TTS for 1 KHz tone is the same whether the ear was tested alone, or both ears simultaneously".

A similar study was done by Ward (1965), he in his study compared the TTS following monoaural and binaural exposures to three different high intensity stimuli. The maximum effect occured at 2 KHz where the binaural exposure gave less TTS as compared to monaural exposure. Ward explained this reduction in TTS in terms of feedback loop and he further reports that "with the increased input when the second ear is stimulated, the total activity of the reflex centre also increases in middle ear muscle activity".

Melnick (1967) found that more TTS occured when the exposure signal was 180 out of phase in his experiment on the effect of two inter aural phase conditions for binaural exposures on threshold shift.

Guiot (1969) showed that stimulation of the left ear had a defenite influence upon the TTS measured on the right ear. If any summation effects were to occur, a reduction of sensitivity should have resulted rather than an increase as was actually recorded. A reasonable interpretation of this outcome can be formulated if one admits that a central inhibitory process, in conduction with fatigue to be intervened in the production of TTS. Inhibition, considered as associating with fatigue to form a response system, should be expected to be affected by some external stimulation, that is to be inhibited when operant. The phenomenon of disinhibition can be revealed by a reduction in TTS. In the same perspective, the disinhibition effects of certain nonauditory stimuli as reported by Rawden Smith (1936) could be cited. Another interpretation of the results obtained in this study could be made. Instead of being based upon the action of a central inhibitory process, the difference in TTS can be explained as if it were the result of a peripheral phenomenon. It is possible that, due to specific ON-OFF paradigm and the time constant for fatigue recovery, the middle ear muscles contract more rigorously in response to alternate binaural exposure than to monoaural stimulation.

Thus, TTS can be shown to demonstrate peripheral and neural effects. Randohph and Gardner (1973) in their study of an interaural phase effect in binaural TTS, showed that if particular neural units in an afferent pathway are constantly stimulated and ultimately fatigued, the post exposure threshold resulting from restimulation of the same neural units would be shifted. Sequentially occuring tonal exposure to test stimuli of like interaural phase might then be expected to produce more TTS than would sequentially occuring stimuli of opposite interaural phase. Since the peripheral exposure and test events at the individual peripheral receptors may be considered identical, such differences, of course, could only be attributed to adaptation or alteration of neural responsiveness and not to peripheral factors.

The results obtained in their study, seemed to be intimately bound to the interactive effects of binaural stimulation and threshold measurements rather than with fatigue of the cochlea receptors. A complex phenomenon involving central interaction of the auditory pathways, including possible efferent action is indicated. The rapid recovery of threshold that was observed in the study in the 1st min. after exposure confirms with the observation of Derbyshire and Davis (1935) that neural discharge rates rapidly increase and reach their original level within about 1 min. following cessation. It is well that the number of higher order fibres activated, may amount for the differences in TTS seen in this study. If particular neural units in an afferent pathway are constantly stimulated and ultimately fatigued or adapted; the post exposure threshold resulting from restimulation of these same neural units may be shifted. Conversely, exposure to test tones of differing interaural phase could, in turn activate different neural units and produce less TTS.

Dichoti exposure to certain acoustic stimuli at high intensity levels results in reduced post exposure TTS relative to monotic exposure to the same stimuli. (Ward, 1965; Melnick, 1967; Karlorich, Lutermann and Abbs, 1972).

Karlovich and Wiley (1974) assumed that the reductions in TTS observed resulted from involvement of the acoustic reflex. The increased effectiveness of the reflex activating stimuli having more rapid repetition rates was not completely clear. But they speculated however that some type of adaptation or 'reflex decay' may be involved in which the acoustic reflex response to continuous or slowly pulsed stimuli diminishes over time more so than the response to stimuli with faster repetition rates.

Shivshankar (1976) has reported that there is no significant difference in TTS between monoaural and binaural exposure to high frequency tones, especially at 3 KHz at TTS_3 . This could be attributed to the action of homolateral olivo-cochlear bundle which might inhibit the responses of the higher centres, as crossed olivo cochlear bundle does not play a role in the adaptation mechanism at high frequency - Dayal (1972).

EAR DIFFERENCE IN TTS:

During the past few years, much attention has been devoted to the study of ear differences in the processing of auditory stimuli. In (1970), Spellacy and Blumstein reported data which suggested that when normal hearing subjects are asked to recall or identify dichotically presented stimuli one ear was said to perform over the other.

Gorden and Zatone (1981) demonstrated that both younger and older bilingual children exhibit significant right ear advantages in processing both English and Spanish auditory stimuli.

Burns and Manning (1981) obtained better performances when the Ward lists were presented to the right ear of the subjects.

Belmore (1981) suggests that the right ear advantage for immediate report usually observed in the dichotic listening situation is a transient phenomenon which is based on phonetic encoding. The left hemisphere seems to be specialized for the initial reception of verbal information, but not for the storage or retention of such information over time.

Shadden and Peterson (1981) found significantly faster left ear reaction times.

William Yund (1932) concluded that no sequential interactions are necessary to produce ear dominance. His conclusions did not support the conclusion made by Deutsch (1980).

Other studies have suggested that when the stimulus is language, the right ear is typically the dominant one (Shankaveiler and Studdert Kennedy (1967) Kimura and Fold (1964) studies by Kimura (1964) and Curry (1967) have suggested that the left ear appears to be the dominant ear when the stimuli are not complex language sounds.

Other studies have continued to explore the phenomena of ear differences in auditory processing.

Ear difference in auditory fatigue has been reported by many authors. Glorig and Rogers (1965) found that the right ear was better in high frequencies and left ear in the low frequencies when TTS was measured after exposure to noise.

Ward (1967) pointed out that the same ear may also exhibit different. Susceptibility to different frequency hands.

Jerger (1970) showed similar differential effects in the TTS in the two ears.

Weiler et al (1974) found that exposures had differential effects on the two ears at the same test frequency. The left ear showed a significant increase in TTS at 4 KHz and a significant decrease in TTS at 500 Hz and 1 KHz. The average TTS was greater at 250 Kz and 500 Hz in the right ear. The left ear had more TTS than the right ear at 1000 Hz and 2000 Hz, and the right ear had more TTS at 4 KHz and 8 KHz them the left ear.

J.Jerger and S.Jerger (1970) found that the post exposure audiograms of two groups of rock and roll musicians showed substantial TTS at high frequencies, especially in the left ear.

Axelson and Lindgren (1977) found a clear difference between the right ear and left ear in that the left ear was better in the high frequencies.

The microscopic physical variation between the two ears inthe posterior or the angle of the cochlear duct relative to the oral window could be responsible for theear difference. Such a difference might cause the fluid pressure waves in the inner ear to stress the sensory structure at a slightly different point (Weiler 1964). Bishnoi (1975) found no ear difference as far as TTS and its recovery are concerned. Shreemathi (1981) has reported that there is no significant difference in TTS between the left and right ear.

The process of fatigue is generally considered to occur in the cochlea. The existance of a central influence on auditory fatigue was, none the less observed by some authors. (Rawson-Smith, 1936, Wernicke and Tobias, 1963; Capps and Collins, 1965; Collins and Capps, 1965; Fricke, 1966; Smith and Loeb, 1967). However, their findings were questioned by several investigators (Causse and Charasse, 1947; Ward and Sweet, 1963; Bell and Stem 1964; Riach and Sheposh, 1964; Price and Oatman, 1967). These conflicting results, which may reflect the fact that the selected procedures were not fully appropriate for demonstrating the presence or absence of a central factor in auditory fatigue, have left this question unresolved.

Rosenzwing (1951) has suggested that the auditory units in each half of the brain fire to stimulation of the ipsilateral ear, same to the contralateral ear, and some to both. More units are activated by contralateral stimulation than by ipsilateral, but in addition to those units which fire to both, the contralateral connections, occlude the ipsilateral connections. Thus, the greater effectiveness of the contralateral pathways should become more apparent when both ears are stimulated but with different materials.

The compound action potential (AP) is often used to evaluated VIIIth nerve function following noise exposure. When the ear is exposed to pure tones at high levels, decrement is measured by the cochlear microphonics (CM) (Babighlan et al 1975) or by brain stem and central auditory potentials (Babighlan et al 1975, Salvi et al 1975). These results were interpreted as having a central origin. For short term auditory fatigue, however Durrant (1976) reported that the summating potential (SP), a peripheral or cochlear potential, is also reduced more than the AP or CM. Because the CM has been shown to be unsensitive to electrical and mechanical modifications of the cochlea than the SP (Durrnt and Gans 1978), it would seen that the SP might be a better index of cochlea function following noise exposure. However, S.P. could be regarded as the better measure only if the extent of its reduction should correspond with that of action potential. This has not to date been demonstrated.

Gans (1980) suggests that the summating potential might be a better indicator of noise induced auditory decement (fatigue?) than the cochlear microphonics. Theories of central auditory fatigue may be based on incorrect interpretation of previously published data obtained from cochlear and neural recordings. Salt, Konishi and Coote (1981) found that continuous noise produced less suppression of cochlear microphonics and a greater suppression of AP than did in part noise of equal energy. A reduction in BP did not accompany CM Suppression with either type of noise exposure. They thus concluded that the suppression of cochlear responses is not predicted by an 'equal energy' rule when impart and continuous noise are compared.

G.Babighian et al (1975) investigated TTS neurophysiologically in order todetermine whether a central factor of auditory fatigue exists and, if so, how it relates to fatigue of the peripheral transducer. Results of his study showed that intense tones produce in the CNS fatiguing effects which are in addition to those generated at the peripheral level (cochlear). There was a larger reduction of the collicular response than of the cochlear response, further more, there responses did not recover to normal value together. These findings are strong evidence therefore that there are central effects produced by intense sounds and that those effects are not simply a reflection of the fatigue occuring at the cochlea.

In 1976 Weiler, Delast and Carnrichael reported significant ear difference using a binaural, simultaneous dichotic adaptation technique. The right and left ears yeilded 3 and 6 dB of adaptation respectively to a 500 Hz adapting tone at 60 dB SPL.

Davis and Weiler (1978) reports that the average adaptation measured for the right ear was 12.55 dB and for the left ear was 4.20 dB. These ear differences and the ones noted in the earlier study, suggest that there is a factor of ear susceptibility in auditory adaptation when using a pure tone stimuli. It also suggests that the loudness function differs depending upon the ear being stimulated. Differences are often found between ears, which also suggests that the beginning point for loudness perception differs somewhat in the average.

From the review of literature on TTS, one can see that no pertinent literature is available regarding ear difference in TTS when the ears are stimulated binaurally. And therefore, this study has been taken up so that some conclusion can be drawn regarding this area of TTS.

METHODOLOGY

METHODOLOGY

SUBJECTS:

Twenty Female subjects having normal hearing in the age range of 18 to 23 years were selected from the student population of T.N.Medical College.

The subjects selected for the study, had no history of any ear discharge, earache, tinnitus, giddiness, headache, brain damage or exposure to loud sounds.

All the subjects had hearing sensitivity within 20 dB HL (ANSI 1969) in the frequencies 250 Hz, 500 Hz, 1 KHz, 2 KHz, 4 KHz, 8 KHz.

INSTRUMENT USED:

Arphi 700 MK-IV serial No.345 audiometer with TDH-39 earphone and circum aural cushion MX-41/AR was used. The audiometer was calibrated according to the specifications given by ANSI 1969.

TEST ENVIRONMENT:

The study was carried out in an acoustically sound treated room at T.N.Medical College. The ambient noise levels present in the test room were below the proposed maximum allowable noise levels.

PROCEDURE:

All the subjects were screened at 20 dB HL in the frequencies 250 Hz, 500 Hz, 1 KHz, 2 KHz, 4 KHz and 8 KHz to find the presence or absence of a hearing loss in both the ears.

The subjects were divided into two groups of ten subjects each.

GROUP-I:

Thresholds were established for 4 KHz for both the ears separately.

The ten subjects were then exposed to 2 KHz tone at 100 dB HL in both the ears simultaneously for ten minutes.

TTS was then determined in the right ear (l) immediately after cessation of the stimulus (TTS_0).

2. After one minute of recovery time (TTS_1).

3. After two minutes of recovery time (TTS_2).

A minimum of 24 hours rest period was given to each subject and the same procedure was repeated to obtain TTS_0, TTS_1 and TTS_2 in the left ear.

GROUP-II:

Thresholds were established for 8 KHz for both the ears separately.

The 10 subjects were then exposed to a 4 KHz tone at 100 dB HL in both the ears simultaneously for 10 minutes.

TTS was then determined in the right ear (1) Immediately after cessation of the stimulus (TTS_0).

2. After 1 minute of recovery time (TTS_1).

3. After 2 minutes of recovery time (TTS_2).

A minimum of 24 hours rest period was given to each subject and the same procedure was repeated to obtain TTS_0, TTS_1 and TTS_2 in the left ear.

The data were then analysed statistically using 't' test of significance.

RESULTS AND DISCUSSIONS

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The results were analysed statistically using 't' test of significance. Tables 1a and 1b, show the temporary threshold shift (TTS_0 TTS_1, TTS_2) at 4 KHz in the left ear and the right ear (fatiguing stimulus 2KHz) respectively. The results show that all the subjects had higher thresholds in the right ear than the left ear at TTS_0.

Tables 2a and 2b, show the temporary threshold shift (TTS_0, TTS_1, TTS_2) at 8 KHz in the left ear and the right ear (fatiguing stimulus 4 KHz) respectively. The results show that while only two of the subjects had higher thresholds in the right ear than left ear, five of the subjects showed no ear difference.

Tables 3a and 3b, show mean and standard deviation for TTS_0, TTS_1 and TTS_2 at 4 KHz in the left and right ears respectively. The mean values of TTS_0, TTS_1 and TTS_2 were found to be higher in the right ear than the mean values of TTS_0, TTS_1 and TTS_2 in the left ear. Tables 4a and 4b show mean and standard deviation of TTS-, TTS , and TTS at 8 KHz in the left ear and right ear respectively. No significant difference in the mean values has been observed. The standard deviation of TTS_0 in the right ear is significantly higher than the standard deviation of TTS_0 in the left ear.

Table-1a: Temporary threshold shifts (TTS_0, TTS_1, TTS_2) at 4 KHz-in the Left ear (Fatiguing stimulus - 2 KHz)

Subject	1	2	3	4	5	6	7	8	9	10
TTS_0 in dB	30	15	20	10	15	15	15	25	15	15
TTS_1 in dB	25	10	15	5	10	10	5	15	10	10
TTS_2 in dB	20	10	10	5	10	5	5	15	10	5

Table-1b: Temporary threshold shifts (TTS_0, TTS_1, TTS_2) at 4 KHz in the right ear (fatiguing stimulus - 2 KHz)

Subject	1	2	3	4	5	6	7	8	9	10
TTS_0 in dB	40	20	30	20	20	35	30	35	35	20
TTS_1 in dB	25	10	5	10	10	25	20	25	30	10
TTS_2 in dB	20	10	5	10	10	20	20	20	25	10

<u>Table-2a</u>: Temporary threshold shifts (TTS., TTSg) at 8 KHz in left ear (fatiguing stimulus - 4 KHz). s ^ ^

Subject	1	2	3	4	5	6	7	8	9	10
TTS_0 in dB	30	25	40	40	45	30	45	40	40	40
TTS_1 in dB	20	15	30	20	30	25	30	35	20	25
TTS_2 in dB	15	10	25	15	20	20	25	30	20	25

Table-2b: Temporary threshold shifts (TTS_0, TTS_1, and TTS_2) at 8 KHz in right ear (fatiguing stimulus 4 KHz)

Subject	1	2	3	4	5	6	7	8	9	10
TTS_0 in dB	45	25	25	35	45	25	45	40	40	55
TTS_1 in dB	25	20	15	20	30	20	30	35	20	35
TTS_2 in dB	25	15	10	15	25	20	25	30	15	30

Table-3a: Mean and Standard Deviation of TTS_0, TTS_1 and TTS_2 at 4 KHz in Left ear.

	Mean	Standard Deviation
TTS_0 in dB	17.5	5.892
TTS_1 in dB	11.5	5.562
TTS_2 in dB	9.5	4.601

Table-3b: Mean and Standard Deviation of TTS_0, TTS_1 and TTS_2 at 4 KHz in Right ear.

	Mean	Standard Deviation
TTS_0 in dB	28.5	7.835
TTS_1 in dB	17	8.882
TTS_2 in dB	15	6.667

Table-4a: Mean and Standard Deviation of TTS_0, TTS_1 and TTS_2 at 8 KHz in Left Ear.

	Mean	Standard Deviation
TTS_0 in dB	37.5	6.77
TTS_1 in dB	25	6.236
TTS_2 in dB	20.5	5.986

Table-4b: Mean and Standard Deviation of TTS_0, TTS_1 and TTS_2 at 8 KHz in Right Ear.

	Mean	Standard Deviation
TTS_0 in dB	38	10.328
TTS_1 in dB	25	7.071
TTS_2 in dB	21	6.583

Table 5 gives the 't' values of significance for TTS_0, TTS_1 and TTS_2 measured at 4 KHz (fatiguing stimulus 2 KHz) and 8 KHz (fatiguing stimulus 4 KHz) in the right and left ear. The results show that, the 't' value at 4 KHz at TTS_0 and TTS_2 were greater than t values given in the table for t test of significance. The t value at 4 KHz at TTS_0 was greater than the fable value for t test of significance at the 0.01 level of significance. The t value at 4 KHz (fatiguing stimulus 2 KHz) at TTS_1 and at 8 KHz (fatiguing stimulus 4 KHz) at TTS_0, TTS_1 and TTS_2 were less than t values given in the table for t test of significance at the 0.05 and 0.01 level.

According to the results obtained from the study, the hypothesis: "There is no significant ear difference in TTS produced by binaural stimulation at equal intensity levels and for equal duration of exposure" has been accepted at TTS measured at 8 KHz, but rejected at TTS measured at 4 KHz.

Thus, the present study shows significant difference in TTS at 4 KHz between the right and left ear for binaural stimulation (2KHz) at equal intensity levels and for equal duration of exposure. But no significant difference was observed in TTS at 8 KHz between the right and left ears for binaural stimulation (4 KHz) at equal intensity levels for equal duration of exposure.

Table-5: Showing 't' test values.

	TTS_0	TTS_1	TTS_2
2 KHz, Measured at 4 KHz	3.55	1.66	2.15
4 KHz, Measure at 8 KHz	0.128	0	0.178

Table value at 0.05 level of significance = 2.10

Table value at 0.01 level of significance = 2.88

DISCUSSIONS:

The present study shows that there is significant difference in TTS at 4 KHz between right and left ear for binaural stimulation using 2 KHz tone and that there is no significant difference in TTS at 8 KHz between right and left ear for binaural stimulation using 4 KHz tone.

Ear difference in auditory fatigue has been reported by many authors. Glorig and Rogers (1965), Ward (1967), Jerger (1970) and Axelson and Lindgren (1977) have reported significant ear difference in TTS. Whereas Bishnoi (1975) and Shreemathi (1981) found no significant difference in TTS between the left and the right ear.

The existence of a central influence on auditory fatigue has been observed by many authors. (Rawson-Smith 1936), Wernicke and Tobias 1963; Capps and Collins 1965; Collins and Capps 1965; Friche 1966; Smith and Loeb 1967).

The existence of contrifugal nerve fibres in the VIIIth nerve was postulated by Onufrowicz in 1885 and Bishaff in 1899. Rasmussen's paper in 1946 defined the efferent component in the innervation of the cochlea. This has been termed the olivo cochlear bundle. There are two components of these fibres to the cochlea from the superior olivory complex.

1) The main crossed olivo cochlear bundle.
2) The homolateral component which joins the main crossed bundle before leaving the brain stem.

The efferent fibres have been traced to higher centres including the cortex. This was reported in man by Gacek.

Galambos in 1956, showed that electrical stimulation of the crossed olivo cochlear bundle in anesthetized cats resulted in suppression of the click evoked nerve action potential. Based on these, Galambos claimed that the olivo cochlear bundle has an inhibitory effect on the cochlear receptor. It was found that the cochlear microphonics response was augmented due to crossed olivo cochlear bundle stimulation, while the action potential response was suppressed.

Studies of the homolateral component of the olivo cochlear bundle have also shown suppression of click evoked action potential recorded at the round window. (Desmedt 1963; Sohmer 1966; Fex 1967); however, no change in the cochlear microphonics potential from homolateral Olivo cochlear bundle stimulation was noted by these authors.

The frequency and intensity dependence of these fibres were studied by Sohmer 1965; Wiederhold and Peake 1966). Sohmer 1965 found that the effect of crossed OCB stimulation was greatest at low intensity and low frequency acoustic stimulation. Wiederhold and Peake's study showed "when the sound pressure levels of high frequency (10 KHz) and low frequency (400 Hz) transcient acoustic stimuli were matched according to a psychological criterion, the neural response to the high frequency stimulus was reduced more by olivo cochlear bundle stimulation than the response to the low frequency stimulus".

Dayal (1972) reported that the crossed OCB had no effect on the adaptation mechanism for high frequencies. This was in contradistinction to the work of Leibbrandt (1965) who with indirect experiments with injection of procaine into the internal auditory meatus, had suggested that the adaptation mechanism was due to the efferent reflex arc activity. It could also be possible that the homolateral component of the olivo cochlear bundle may play a part in this mechanism; however, it is known that greater inhibition of the action potential occurs with the stimulation of the crossed olivo cochlear bundles.

Dayal (1973) reports the action of crossed OCB at high frequencies and has revealed that, the COCB is not responsible for adaptation at high frequencies.

The results of the present study that significant ear difference in TTS at 4 KHz for binaural stimulation at 2 KHz and no significant ear difference in TTS at 8 KHz for binaural stimulation at 4 KHz can be explained in the light of Dayal's (1972) findings that crossed olivo cochlear bundles do not play any part in the adaptation mechanism at high frequencies. This absence of the inhibitory effects at high frequencies could be responsible for no ear difference in TTS at 8 KHz (stimulating frequency 4 KHz)1

Since ear difference was found in TTS at 4 KHz (stimulating frequency 2 KHz) the crossed OCB could be responsible for the ear difference in TTS.

Thus the present study reveals that the ear difference does exist in TTS for binaural stimulation using 2 KHz tone. TTS observed in the right ear is significantly greater than the TTS observed in the left ear. As mentioned earlier, the difference in TTS between the right and left ears might be due to the action of the efferent auditory system. The fact that the right ear shows more TTS than the left ear is an indication that the action of the efferent auditory system during binaural stimulation is more intense in the right ear than in the left ear.

SUMMARY AND CONCLUSIONS

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The present study was aimed at investigating whether there is any significant ear difference in TTS when both the ears are stimulated simultaneously at equal intensity level and for equal duration of time.

The Arphi 700 MK IV audiometer with TDH-39 earphone and MX-41/AR circum aural cushion, calibrated according to the specifications given by ANSI 1969 was used for the study. 20 normal female subjects used in the study were divided into two groups of ten subjects each. TTS_0, TTS_1, TTS_2, were measured in group-I at 4 KHz in the right ear and the left ear separately after they were being exposed to a fatiguing stimulus (2 KHz at 100 dB HL) continuously for 10 mins. In group-II, the fatiguing stimulus used was 4 KHz at 100 dB HL and TTS_0, TTS_1, TTS_2 were measured at 8 KHz in right and left ears separately.

CONCLUSIONS

1a) There was significant difference in TTS_0 at 4 KHz between the right and left ears for binaural stimulation using 2 KHz tone at 100 dB HL for 10 min. continuous exposure.

b) There was no significant difference in TTS_1 at 4 KHz between the right end left ears for binaural stimulation using 2 KHz tone at 100 dB HL for 10 mins. continuous exposure.

c) There was significant difference in TTS_2 at 4 KHz between the right and left ears for binaural stimulation using 2 KHz tone at 100 dB HL for 10 mins. continuous exposure.

2a) There was no significant difference in TTS_0 at 8 KHz between the right and left ears for binaural stimulation using 4 KHz tone at 100 dB HL for 10 mins. continuous exposure.

b) There was no significant difference in TTS_1 at 8 KHz between the right and left ears for binaural stimulation using 4 KHz tone at 100 dB HL for 10 mins. continuous exposure.

c) There was no significant difference in TTS_2 at 8 KHz between the right and left ears for binaural stimulation using 4 KHz tone at 100 dB HL for 10 mins. continuous exposure. ^

3) Absence of ear difference in TTS at 8 KHz (fatiguing stimulus 4 KHz) may be explained in terms of Dayal's (1972) observation that the crossed olivo cochlear bundle has no effect on the adaptation mechanism at high frequencies.

4) The significant difference observed in TTS between right and left ears at 4 KHz for binaural stimulation using

2 KHz tone at 100 dB HL for 10 min. continuous exposure, may be due to the influence of crossed olivo cochlear bundle.

5) The action of the efferent auditory system appears to be more intense in the right ear than the left ear during binaural stimulation as the subjects showed greater TTS in the right ear than the left ear.

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