To

My Family

ALBRECHT'S EFFECT IN NORMAL HEARING SUBJECTS

Reg.No.8

An Independent Project work Submitted as Part Fulfilment

for First Year M.Sc., (Speech and Hearing) to the

University of Mysore

ALL INDIA INSTITUTE OF SPEECH AND HEARING

Mysore - 570 006

CERTIFICATE

This is to certify that the Independent Project entitled.

"ALBRECHT'S EFFECT IN NORMAL HEARING SUBJECTS"

is the bonafide work, done in part fulfilment for First year M.Sc., Speech and Hearing, of the student with Register Number:

Director,

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CERTIFICATE

This is to certify that the Independent Project entitled:

"ALBRECHT'S EFFECT IN NORMAL HEARING SUBJECTS"

has been prepared under my supervision and guidance.

(GUIDE)

May 28/1981

D E C L A R A T I O N

This independent project entitled

"ALBRECHT'S EFFECT IN NORMAL HEARING SUBJECTS"

is the result of my work undertaken under the guidance of Mr. P.J.Kumar, Lecturer in Audiology, All India Institute of Speech and Hearing, Mysore - 570 006, and has not been submitted at any University for any other Diploma and Degree.

MYSORE MADHURI GORE

DATED: **Register No.8**

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CHAPTER - I

INTRODUCTION

Abnormal auditory adaptation has been of diagnostic interest to the clinical audiologists while diagnosing a case of retrocochlear pathology. It is reflected while using tone decay tests in the diagnostic battery.

It is known that continuous stimulation of the auditory system using pure tones at thresholds level results in the disappearance of the same (tone) after a while. Discovery of this phenomenon has been credited to Albrecht by Kobrak et al. (1941).

Albrecht's effect appears as a tendency of the threshold to rise gradeally when the tone is continuous but not interrupted, (Ward, 1963). This phenomenon is referred to by many terms, but the term generally used now is 'Tone Decay'.

Tone Decay then referred, to the decrease in threshold resulting from the presence of an audible sound. It can be measured at threshold or supra threshold levels. It is the threshold level tone decay that is referred to as Albrecht' effect and they are used in synonym in the present study.

Albrecht's effect is said to have taken place, when a subject reports that a tone presented to his ear, at his hearing threshold level continuously, and without any interruptions? has disappeared. That is to say, when a tone is presented continuously without any interruptions at threshold level it disappearsafter a while.

The above phenomenon has also been reported in terms of threshold tone decay or the "decrease"in threshold sensitivity resulting from the presence of a barely audible sound." (Green,, 1978).

The supra threshold tone decay tests are used in cur present clinical situations to identify retrocochlear pathologies. In these tone decay tests, the magnitude of tone decay is usually expressed in terms of the number of dBs in relation to the appropriate limit of the time prescribed at a supra threshold level. The results expressed are in terms of the number of dBs above threshold at which a criterion of prescribed time limit is met. This has the diagnostic significance.

As the amount of the intensity has a diagnostic significance, so also, the time may reflect the pathology in the auditory system. This is very well reflected when one used the Owen's modification of Hood's (1956) tone decay test where, the rapidity and amount of decay are analysed to obtain valuable diagnostic information.

Still, this test (Owen's 1964) provides for the Rapidity of decay only at supra threshold levels (5dB SL).

However, the literature that is available here has no mention of any study that has studied the threshold level tone decay expressed in terms of the duration of decay.

Hence the present study:-

The aim of the present study is to measure the duration of decay of a tone that is presented continuously, without any interruptions at the hearing threshold of a subject.

It is planned to use the normal subjects in the present study as there are no studies in out literature giving to an idea about the range in duration of decay at threshold level.. It is reported else where that the normal hearing subjects show a maximum of 5 - 10 dB of tone decay (Willeford, 1960, Sorensen, 1962, Yantis and Owens 1964). This is of help in our diagnosis because we know that any decay above this range is abnormal. This provides for a normal comparitive data.

In the same manner, we have no normative data to reflect the amount of duration. Hence the present study's main aim is to obtain data with normals.

This will be of help when studies are taken with pathological subjects. The results of the present study can be easily used for comparison.

The "duration of decay" in the present study refers to the amount of time that a subject required to report that the tone presented continuously and without any interruption at his threshold level is no longer heard.

The study also aims to answer the following questions:

1. What is the duration for which a tone of given frequency is heard at threshold level?
2. Does the frequency of the test tone influence the duration for which a tone is heard before it decays into, inaudibility?

To be more precise the present study is an effort

a) to know the duration of decay at threshold level.
b) to understand whether this duration is, or is not, frequency dependent.

Hence the following hypothesis that "The duration for which a tone is heard at threshold is independent of its frequency," will be examined.

It has been reported else where, that the amount of decay in terms of dB varies with frequencies. ie.. the amount of decay increases with increase in frequency, of the stimulus used, (Doehring and Swisher, 1971, Morales-Gracia and Hood 1972). Because of this it is expected that the duration of decay should be also varying with frequency.

For the purpose of obtaining the duration of decay, .. normal hearing young adults will be administered, a modified form of the threshold tone decay test. The amount of time taken for the disappearance of the tone at threshold will be recorded at 500 Hz, 1000 Hz, 2OOO Hz, 4000 Hz and 8000 Hz.

The data thus collected will be analyzed statistically.

Implications:-

1. It provides information which will be helpful for further research in this area.
2. It provides data in terms of duration of decay at threshold at different frequencies within its limitations.
3. If the expected results are arrived at, the time consumed in administering the tone decay test will be greatly reduced. If we are able to collect the data about the duration of decay, in different pathological cases and we can compare the same with the present and the other enhanced data with normals.

Limitations of the present study:-

a) It is only a pilot study.

b) It will be done only with a limited number of subjects for want of time, hence we may not be able to generalize the results.

c) The results that will be arrived at in the present study will be limited to this study.

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CHAPTER - II

REVIEW OF LITERATURE

At the onset, it is important to differentiate Tone Decay from other aspects of Adaptation.

Auditory adaptation is a complex process. It refers to any change in the functional state of the auditory system and is manifested in a number of ways.

Classically, the phenomena included under a adaptation could be distinguished in two different ways, (Ward, 1973).

a) Concomitant - (Observed during exposure to the acoustic stimulus) or Residual (observed after exposure to the acoustic stimulus).

b) Monaural - (requiring one ear for its measurement)or Binaural - (requiring both ears for measurement).

The phenomenon of Tone Decay is thus associated with a number of terms which include auditory threshold fatigue temporary threshold fatigue (Kos, 1955), abnormal adaptation (Carhart, 1957), Pathologic relapse (Hood, 1956), Temporary threshold shift (Lierle and Reger, 1955), slow adaptation (Sorensen, 1962), Tone perversion (Parker, Decker and Richards, 1968), Perstimulatory auditory adaptation (Palva, 1964), Threshold drift (Harbert and Young, 1962) and Pathologic fatigue (Flottorp, 1963).

These terms cannot be used interchangeably with Tone Decay, but if the signal being discussed is at or near threshold, it may be safely assumed that these concurrent changes relate to the tone decay phenomenon. As has been mentioned earlier, Albrecht's effect appears as a tendency of the threshold to rise gradually, when the tone is continuous, but not interrupted, and hence may be used synonymously with threshold tone decay here.

Following the "Classical classification" given earlier Tone decay is a concomitant Monaural type of adaptation.

Differentiation of Tone Decay from similar phenomena:-

Tone Decay can be differentiated from similar phenomena in terms of recovery period and method of measurement.

Tone Decay and Fatigue:-

The major distinction between the two is that fatigue effects last longer and can be measured after the fatiguing stimulus is discontinued. Effects of Tone Decay on the other hand recover very rapidly.

Auditory fatigue, when used without explicit definition usually refers to temporary threshold shift, TTS.

Measurement of TTS:-

TTS is a residual monaural phenomenon and is measured as follows: A Fatiguer is presented for a time T. Then the test stimulus of duration r is presented, at a time t after cessation of the TTS arousing stimulus. The change in detection threshold for the test stimulus, relative to the "resting" (Pre-exposure) threshold in decibels is the threshold shift.

The duration of TTS is usually related monotonically to the intensity and duration of the fatiguer. The fatiguer nay be interrupted and the TTS may be sound by finding the threshold of a pure tone presented in the pauses (ultra short term TTS : Residual Masking) or may be of a moderatelevel i.e., below 85 dB SPL. In the latter, the TTS persists for a couple of minutes. Another property of TTS is that it increases with exposure time but by 1 min. has essentially reached its maximum value., TTS seldom exceeds 15dB. Physiological fatigue however, reaches values of 30dB & recovery here may take upto 16 hours. TTS may thus be long lasting. This is seen when exposure to noise is present for several hours. This is pathological fatigue. It is also accompanied by perceptual changes in pitch. The affected ear heard the sound as "flatter" (lower in pitch) in a general sense.

Tone decay and Perstimulatory fatigue:-

Tone decay is often confused with perstimulatory fatigue. Perstimulatory fatigue was the first aspect of auditory adaptation to be described. This confusion primarily exists because of the assumption that the "phenomenon is based primarily on a reduction in loudness in the exposed ear" (Ward, 1973).

Dove demonstrated that if one ear were exposed to a tone for some time, then introduction of the same tone simultaneously into the other (control) ear, resulted in the perception of a tone only in the latter.

It is difficult to decide if the Loudness of the tone in the exposed ear decreased or if the characteristics of the ear shifted so that "a tone in that ear no longer had the same lateralizing power as at the begining of the exposure," (Ward, 1973). It is thus difficult to decide if the phenomenon is peripheral or central. A number of studies indicate that it is probably central.

Flugel found that the two ears of a given observer often displayed different degrees of asymptotic adaptation at a given frequency. He then argued that when the tone was presented binaurally, the loudness in the more susceptible ear should decrease. But no such shift occurred, indicating a complicated central mechanism.

Mirabella et al (1967) asked the subjects to keep the loudness of a sustained tone constant and found that at 70dB SPL, the upward drift in 10 mins, was 3.5dB and at 90 dB, there was a downward drift, implying that, loudness was increasing.

In the perstimulatory adaptation paradigm however, a 20 - 50 dB imbalance is observed (Ward, 1973). This indicates that perstimulatory adaptation appears only when both ears are simultaneously stimulated, and has nothing to do with the adaptation of cochlear receptors. Tone Decay on the other hand is a monaural phenomenon and is measured with monaural stimulation under the following conditions:-

1. The stimulus is a pure tone instead of a noise. (irregularity helps to minimize growth, Carterette, 1956).

2. The control ear is given a pulsed instead of a continuous tone (this keeps the effect from diminishing during the process of testing for it, Wright, 1960).

3. The adapting stimulus is continuous.

4. The instructions emphasize median plane balance rather than "equal loudness" (Stockinger and Studebaker, 1968).

5. When the test subjects are adults, (Children between the ages of 7 to 15 years did not demonstrate much adaptation, (Karjer, 1968).

This phenomenon was negatively correlated with TTS (Tanner, 1955), but has not been reduplicated.

In terms of recovery from adaptation too. Tone Decay differs from perstimulatory adaptation.

"Threshold Tone Decay recovers within a few seconds following the cessation of the signal. The recovery is too fast to be classified as perstimulatory adaptation..............,.,.," (Sergeant and Harris, 1963).

Tone Decay and fast Adaptation:-

Sergeant and Harris (1963) classified tone decay as a "Unique category" of adaptation based on the threshold of recovery. They said that the recovery of Tone Decay following cessation of stimulus was slower than that of fast adaptation.

Fast adaptation has a brief onset (300 m.secs or less) and recovery, and its locus which is the hair cells, as well as its insensitivity to cumulative effects. It is measured with clicks and is a function of inter-click interval.

Thus, the inconsistencies in terminology can be ruled out by differentiating between

(a) The method of measurement of the phenomenon and the conventional method used to measure tone decay and

(b) The threshold recovery period.

As has been mentioned earlier, Tone decay can be measured at both threshold & supre-threshold level. Threshold tone decay appears as the decrease in threshold sensitivity resulting from the presence of a barely audible sound? supra threshold tone decay is a decrease in threshold resulting from a sound well above the threshold.

In this project, it is the threshold tone decay which is being measured.

Tone decay measurements are usually made with a conventional pure tone audiometer and can be applied to any available frequency. The quantity of tone decay is expressed as the difference between the initial threshold and the threshold at which the test is terminated. This difference is expressed in dB.

The methods of measurement of Tone decay are based on the early observations made by many investigators.

After the discovery of this phenomenon, several other discoveries were made. In 1890, Corradi demonstrated that Tone decay occurs in Bone conduction. Oradenigo (1893) observed that patients with acoustic tumours responded to a maximally vibrating tuning fork for only a few seconds.

Dunlop reported the off-effect noted in Tone decay tests. His subjects listened to a sound "emitted by telephone receiver", at threshold intensity. Their task was to indicate when the signal was absent. Dunlop reported that almost half the subjects reported hearing the tone cease, when it was turned off (The signal was turned off after the subject reported it to be inaudible).

Conflicting results were also reported.

Schafer(1905) noted that not everyone experiences tone decay, even at higher frequencies. He could hear Lord Rayleigh's bird call indefinitely.

Rhase (1906) found no consistent difference between normal ears and persons with middle ear pathology. Similarly Bleyl(1921) found no differences between persons with normal hearing, oonductive losses, perceptive losses and "miscellaneous".

Research on tone decay came to a standstill after these early reports.

Then in 1944, K. Schubert, used a conventional audiometer to measure tone decay. The procedure he used was as follows:

The patient was allowed to listen to a tone at 5 dB SL until it disappeared. Thereafter, the intensity was raised in 5 dB steps without interruption until a plateau was reached or the maximum limit of the audiometer. He found that for normal ears of young people (under 30 years) there was no effect at frequencies below 1KHz. At higher frequencies, slight effects were seen.

In individuals with inner ear deafness, the effect was grossly exaggerated.

Hood(1956) reported a more elaborate procedure. The subject's threshold of hearing for an interrupted tone was obtained and the subject was instructed to raise a finger as long as he hears the bone and to lower it if it faded into inaudibility.

The test was begun at 5dB above the threshold. When the tone was reported to be inaudible, a 60 second rest period was given and the intensity of the tone raised by 5 dB and the procedure continued until a tone was heard indefinitely.

It was not until 1957, that a formal clinical test was developed to measure tone decay.

This test is conducted in a number of steps.

1. The subject's threshold of hearing is obtained for an interrupted tone.
2. The subject is instructed to raise his finger as long as he hears the tone and to lower it if the signal fades into inaudibility.
3. The test is begun with a sustained tone, below the established threshold and ascend in 5 dB steps without interruption until the subject responds.
4. As soon as the subject responds, timing is begun with a stop watch. If the tone is heard for a full minute, the test is terminated.
5. If the subject indicates that he no longer hears the intensity of the tone is raised by 5dB without interrupting it and the stop watch set back to zero to begin timing for a minute again. A record is Kept of the number of seconds, the tone is audible at each intensity.
6. The test is continued until the tone is heard for one minute. The test is terminated at 30dB SL even if the tone is not perceived for one full minute.

Most testers using the Carhart procedure, begin the test at threshold or at 5dB above the threshold.

This test served as a base for a number of other tests. Olsen & Noffsinger (1974) suggested beginning the test at 20dB SL. They also stressed the importance of requiring a response to "tonality" as opposed to response to "any sound" during tone decay testing.

This 20dB SL technique was as sensitive as Carhart's procedure in identifying excessive tone decay. Carhart's method was shortened by Rosenberg(1958). He limited the exploration given to any given tone to 60 seconds. The threshold was found similarly and the instructions were similar. If the subject indicated that he no longer heard the tone, the inteasity was raised 5dB without interrupting the stimulus or stopping the watch. This was continued and at the end of a total of 60seconds, the tone was turned off and the amount of decay in dB is computed.

In 1963, Green modified the instructions given with the shortened l minute version of the Carhart test. He noticed that some patients with retro-cochlear lesions experienced a loss of tonality before the loss of audibility on the tone decay test.

The patient is seated in an arm chair and told to maintain elbow contact with the arm rest while he signals. If the stimulus loses tonality, but is audible he is trained to lower his arm to a 45° angle and to lower his arm to the rest position if the sound becomes inaudible. The patient is cautioned against adjusting the earphones or chewing while the test is in progress, since the slightest interruption in the continuity of the stimulus can impair test reliability. A response to perception of tone is felt to enhance the sensitivity of the test.

This change in the quality of the tone has been called tone perversion by Parker et al (1968) and a number of other investigations. Jerger and Jerger worked on the hypothesis that the symptoms of abnormal tone decay first appear only at the highest testable sound intensities. In 1975, they proposed the "supra threshold adaptation test" (STAT). The test frequencies are 500, 1K, 2K in that order.

The subject is instructed to signal as long as he hears the sound in the test ear. The non test ear is masked with white noise at 90 dB SPL.

The test tone is presented at 110 dB SPL until the patient indicates that he no longer hears the tone or 60 secs have elapsed (which ever comes first). The test is scored - ve if he hears it for 60 secs but +ve otherwise. To ensure that he has understood the task, a pulsed tone is given at the same level. If he responds, he is responding to the test in a reliable manner. The 110 dB SPL are roughly 100 dB HL at 500 Hz and 2KHz and 105 dB HL at 1KHz.

Owens (1964) modified the Hood technique, incorporating a 20 sec rest period between stimulus presentations. He provided both the amount of tone decay upto 20 dB SL and the pattern in seconds, at succeeding levels for categorization into normal,cochlear and retro cochlear types.

The tone decay patterns the obtained are given below:-

Levels above threshold	Patterns Of Decay						
	Type I	Type II					Type III
		A	B	C	D	E	
dB							
5	60	25	7	12	15	5	14
10		60	34	26	23	14	16
15			60	40	30	18	12
20				60	29	21	14

The numbers in the table represent the seconds of time the tone was heard at the intensity level indicated before fading to inaudibility.

Other variations were reported by Sorenson (1962) who used a 90 sec criterion for terminating the test and confined his test to a single frequency - 2KHz.

These are the conventional methods of measuring tone-decay. Despite their wide spread use, systems of classification are few.

Rosenberg (1958) devised a gradation based on the number of dB of tonedecay resulting from application of his procedure.

0 to 5 dB - Normal
10 to 15dB - Mild
20 - 25 dB - Moderate.
30 dB or more - Marked.

The type I category of Owens is considered normal. A number of authors agree that 5 to 10 dB of tone decay is seen in normals, Jerger and Jerger (1975) state that tone decay as high as 15 to 20 dB is sometimes seen even in normals.

In the pathological group, Owens found that Types I and II are characteristic of Meniere's disease and Type III characteristic of a cranial nerve VIII lesion. Types I, II, and III he said could be correlated to Bekesy audiograms.

Morales - Grancia and Hood, 1972, used a 4 type classification system based on the Carhart tone decay test results.
Type I was minimal and did not exceed 15 dB.
Type II - slightly greater tone decay.
Type III - More that 20 dB at 500 Hz, 25 at 1KHz, 30 at 2KHz and 35 at 4KHz.
Type IV - Similar to type III, but more rapid in decay.

There is no standard system of classification, but marked tonedecay is characteristically found in patients with retrocochlear lesions. The data does not provide much information about the phenomenon in normals. Due to the paucity of literature available, the investigator has been forced to supplement information known about normals with that gathered from pathological oases.

Mechanism of Tonedecay:-

Tone decay is a normal phenomenon. The mechanism of tonedecay is not exactly known, but many speculations have been made. All these speculations are based mostly on studies on pathological groups.

Marked tone decay was found in patients with retre-cochlear pathology; Abnormal tone decay can be caused by neural degeneration, inflammation, trauma, as well as space occupying lesions like tumors which press against the VIII nerve.

The etiologies that can manifest tonedecay are acoustic tumour, primary cholesteatoma, meningoma(Johnson, 1966) thermal injury to nerve VIII (Harbert and Young, 1962), Multiple scelerosis, mumps, neuritis, Von Recklinghausen's disease, acquired genetic deafness, Ramsay Hunt syndrome, intra cranial aneurysm, head trauma, (Harbert and Young) Pinealoma (Kos 1955), Nerve IX neuroma (Naunton.et.al, 1968) Cerebellar atrophy (Miller and Daly, 1967), Extraaxial brain stem lesion (Jerger and Jerger, 1974).

Reversible tone decay has been described in nerve VIII neuritis, multiple scelerosis, pineacoma and Cerebellar atrophy or cerebellar tumour (stroud and Thalamann, 1969). Such a wide array of etiologies causing abnormal tone decay has caused a number of speculations about the mechanism and locus of tone decay.

Mechanism of Tone Decay in Pathological ears:-

Tone decay is associated with both decrease in loudness as well as a change in tonality. Any theory about the mechanism of tone decay must explain both these factors.

The underlying physiological correlate of tone decay is generally assumed to be an absence of neural elements to fire continuously.

They fire normally at the onset of a tone or in response to a sudden change in level, but if the level is sustained, then activity ceases.

This initial burst of auditory excitation or On effect is followed by adaptation, ie. progressive reduction in excitation to sustained stimulation was observed in a number of cases. Hallpike and Hood 195l emphasised this on effect. This is analogous to the Wedensky inhibition of peripheral nerves. It was found that if a short stretch of nerve was partially narcotized, the first impulse of a series or a entire series of impulses would pass through successfully, but a rapid sequence would fail after the first impulse or first few impulses.

Davis(1962), based his hypothesis on this phenomenon. He said that Wedensky's narcotically induced block was similar to the partial dysfunction of a large number of nerve fibers from a retro cochlear lesion. The gradual slowing of recovery and failure of complete recovery during continued stimulation would cause "programme failure of more and more of the impaired fibres."

This model accounts for the simultaneous loss of tonality and audibility.

Another condition exists in which the fatiguing signal loses tonality but not audibility. It is postulated that there is less impairment of function when tonality but not audibility is lost.

This statement is borne out by some observation on a case with sudden deafness with complete recovery. Harbert and Young (1964) found that while the patient began to recover, tone decay tests with the subjects responding to any sound, showed a reduction in the amount of tone decay, but when instructed to respond to tonality, little improvement was seen until further recovery took place.

This phenomenon may be explained from the travelling wave and Volley theories (Green, 1978). If the place of maximal stimulation on the basilar membrane and adjacent areas is "served" by a large number of defective fibres, the stimulating tone will fail to be sustained, and the adjacent areas to which the signal spreads, will exhibit a lack of response, no that tonality and audibility fade out.

If the adjacent areas have intact reserve fibres however, they would maintain the junction for an additional period of time and so audibility but not tonality would be preserved.

The off effect is often seen in tone decay. The tone loses both audibility and tonality, but the patient becomes aware that the tone has been with drawn, as soon as it is discontinued.

This effect is due to the neural off fibres found in the vertebrate ears and eyes, which are activated when sound or illumination ceases.(Harbert and Young, 1962)

This, is the mechanism of tonedecay in pathological ears? what then is the mechanism in normal ears? For, tonedecay, is seen in normals also but to a certain extent.

TONE DECAY IN NORMAL EARS:

It cannot be denied, that what is seen in pathological ears, probably exists in normal ears in a different degree. Pathologies, as has been found earlier, often help to determine the normal function.

To understand what happens in tonedecay, a parallel may be drawn between tone decay and the disppearance of a steadily fixed visual target. If the target stimulates precisely the same area of the retina at all times by what ever means, then, after a few seconds, the target disappears.

Matthew's (1931) work demonstrates this effects clearly. He found that when a stimulus is applied to the ear end organ, the Action Potential response consists of an initial high frequency discharge known as "Oneffect". The duration of this initial burst of impulses is brief, in the order of 0.2 seconds, and is followed by a slow dicline in the discharge frequency with time. This decline is independent of the intensity of the stimulus and can thus occur at either threshold or supra threshold levels.

Tone Decay and Threshold:-

Hood noticed that a tone presented at low or near threshold intensity levels decayed, but "with higher intensities, the persistence of sensation is indefinite."

This suggests that the auditory system requires a certain level of stimulation to maintain its response at. one level, indefinitely. This level is the aame, regardless of whether the tone is initially presented at threshold or at any other value. (Olsen and Noffsinger, 1974).

This may be as in pathologies of VIII nerve, where a certain number of the fibres are under continuous stimulation and may be in an "absolutely refractory stage." (Sung, et. al. 1967).

These fibres probably respond to low intensity. As the intensity increased, fibres which required a higher level of intensity were brought into action and since were larger in number, would then sustain the perception. This critical level of the stimulus above the threshold is what is found when the Tone Decay tests are administered. In normals it has been found that at a level 5 to 10 dB above threshold, a tone is sustained for one minute at least. (Willeford, 1960 and others). This indicates that the duration for which a tone is sustained at threshold level increases very rapidly for every decibel increase of presentation upto this critical points ie. 5 to 10 dB SL generally.

Thus, the accuracy with which the hearing threshold is established will affect the result, (Langenbeck 19).

The most common index of adaptation is time, and in the tone decay tests, the time for normalcy, (upto a certain sensation level of presentation of course) is fixed to 60 seconds. Beyond 30dB SL, decay is pathological.

It would be interesting to find out, how long the auditory system can sustain the sensation of hearing at threshold level. Tonedecay was found to increase with threshold (Morales Garcia and Hood, 1972).

Tone'Decay and the SPL of the test tone in Sensori-neural and conductive hearing loss:-

In 1971, Doehring and Swisher, studied the relation of tonedecay as a function of the SPL of the test tone in SN loss. They found that Tonedecay, tended to increase with increasing threshold level when both Rosenberg test and Bekesy audiometry were used, at all frequencies. The tendency of tonedecay to increase as the threshold increased to 80dB, confirms Owen's finding that tone decay seldom occurs with threshold levels below 35dB for frequencies below 2KHz. This relation does not hold good in conductive loss. Sorenson found essentially no tonedecay present in persons with conductive loss.

It is agreed that persons with sensori-neural loss that is cochlear, do exhibit some decay, that is a little more than normals, but this is stabilized with increasing sensation levels. Eg. Meniere's Disease.,

At 20 to 30 dB SL, persons with cochlear loss percieved a tone indefinitely (Hood). Types I and II categories as described by Owens (1964) are characteristic of Meniera's Disease.

Rosenberg (1967) indicated that mild to moderate levels of Tone Decay were seen in pathology involving the organ of corti, but "marked tone decay, almost always" indicated retrocochlear pathology.

Tone Decay and Frequency:—

Available data on normal ears show a definite frequency effect. Carles Morales-Garcia and J.D.Hood (1972) found no tone decay was markable at the test frequency 500 Hz. At the test frequency 1KHz, 10 out of 41 ears had a slight "threshold shift" of 5 dB, at 2 KHz, 10 out of 41 had a 5 dB shift and 2 had a 10 dB shift, and 3 had 15 dB shift. While no definite correlation was seen at 1 KHz, 2 KHz between hearing levels and the amount of tone decay, it was found that at 4 KHz, the proportion of ears with some delay clearly exhibited increased thresholds. It may thus be concluded that tone decay was no greater than 5 dB at 500 Hz and 1 KHz and no more than 10 and 15 dB at 2 KHz and 4 KHz. The magnitude of tonedecay increased with frequency, but one must not forget the additional factor of hearing threshold involved.

The frequency effect is more clear in pathological ears. Generally,, tonedecay in retrocochlear pathology is marked in the higher frequencies. This, however, is due to the organi- zation of nerve fibres in the auditory nerve, with fibers from the base of the cochlea on the outside and entering the cochlea in the dorsal position(Neff et al).

Doehring and Swisher (1971) also report that higher tonedecay was seen at 4 KHz on the modified Rosenberg, as compared to other frequencies.

Tonedecay, was smaller for 500 Hz at hearing threshold levels below 60 dB and their increased to the level of other frequencies above 70 dB. They report no difference between a KHz and 4 KHz at any threshold level.

Owens found that tonedecay seldom occurs for frequencies below 2 KHz when thresholds are below 35 dB. Katinsky et al (1972), Silman et al (1978) report a similar effect. Low frequencies are rarely affected. Impairment in the pons or higher levels may cause a pronounced decay at one frequency (Morales - Garcia and Hood 19723.

Tone Decay and Masking:-

Contralateral masking influences the measurement of tonedecay. Shimizu (1969) measured tonedecay at 500 Hz, 1000 Hz and 2000 Hz in 11 normal hearing subjects and in 34 with moderate, unilateral conductive loss with 40 dB SR of contralateral masking, a level low enough to avoid over masking, there was an increase in tonedecay. At 2 KHz without masking, only 7% of the subjects had 10 dB of tone decay, but with masking 77% of had 10 to 40 dB of tonedecay.

One patient with unilateral sensori neural loss, showed 10 dB of tonedecay at 1KHz without masking. With 40 dB SL noise in the contralateral ear, there was 30 dB tone decay and with 60 dB SL, there was 50 dB of decay.

Snashall (1974), Blegal (1972) also report that contralateral noise affects tonedecay. Blegal reported a greater separation of Bekesy tracing with contralateral noise and this was frequency dependent.

Snashall reports that greatest masking effect was seen on Carhart's tonedecay test. 10% of normals showed less tone decay on Owen's test and 20% showed less decay with Bekesy. He found however, that adaptation tests at 20 dB SL showed similar effects to noise at other levels. Since these levels of masking were not high enough to cause over masking, central factor was attributed as cause for this effect.

The effect of masking on tone decay cannot be ignored.

Interaction of Tone Decay with Special Tests:-

Tone Decay and Bekesy:-

The most obvious manifestation of tonedecay is in Bekesy audiometry, when the test tone is continuous. This effect is seen in both fixed frequency and sweep frequency tracings. Fixed frequency is more sensitive. Reger and

Kos (1952) noted that the indicated threshold gradually shifted to a higher and higher intensity.

The magnitude of tonedecay is dependent on stimulus parameters. Attenuators with step sizes of 1 or 2 dB bring about the on effect. Tonedecay is manifested in Type III and Type IV Bekesy tracings.

The Critical off time is very important. Harbert and Young (1962) showed that for an interrupted tone, the Bekesy tracings are sharply dependent on the off-time. With decreased off-time, the threshold increased and the tracings were similar to the tracings obtained for continuous tone. Jerger and Jerger (1966) report critical off times ranging from 200 m.secs to 40 m.secs.

Dallos and Tillman (1966) found that frequency modulation with a slow modulation rate (less than 10 per second) and a frequency range of 40 Hz was needed to prevent tonedecay in the continuous tracing at 500 Hz. Bekesy audiometry however, is not very sensitive to abnormal tonedecay.

Tonedecay and DL:

Plath (1973) believes that the Difference Limen for intensity is an indicator for adaptation and fatigue in the auditory function. He believes that with the SISI test,, adaptaticnal changes of hearing are also measured. This is evidenced by the fact that the 6-th to 20-th increments are heard more often than the first 5 increments. He justifies this assumption on the fact that adaptation of the sensory cells of corti occurs in milliseconds. Thus, the described adaptation time of 30 seconds of tone stimulation, for intensity DL must be influenced by a more central adaptation process, with a longer time constant.

Jerger (1955) reports high SISI scores in a patient with retrocochlear pathology. Because of the decay of the carrier tone, the 1-dB increment pips, appear to emerge from silence. The 5 sec interval between the pips, allows for sufficient recovery to take place.

Even ears exhibiting moderate tonedecay, (20 dB) either with cochlear or retrocochlear pathology, exhibit this phenomenon (Hughes 1968). This effect is possibly be demonstrated in normals if the contralateral ear is masked.

Tone Decay and ABLB:-

Masked tonedecay impairs loudness growth with increasing intensity, loudness growth, that is less than normal is termed decriment. (Fowler, 1965) or reverse recruitment (Dix and Hallpike, 1960).

Tone Decay and Acoustic Reflex:-

Tonedecay is associated with elevated reflexes as well as an abnormal reflex decay.

Tone Decay and Word Discrimination:-

Since many fibres are needed for the effective transmission of speech signals, marked tone decay often affects speech discrimination. Thus, word discrimination is much worse than the pure tone thresholds indicate.

Patients fitted with hearing aid, may complain that the hearing aid loses its clarity after using it for some time. After resting for several hours the hearing may again seem clear, (Goldberg, 1964). This also affects language development significantly, (Costello and Mc Gee, 1967).

Tone Decay and ERA:-

Retrocochlear lesion causes longer latency and smaller amplitude in the acoustically looked response, (Schimizu, 1968). This may be due to the fact that the passage of nerve impulses was disturbed by pressure on or destruction of the 8th nerve.

Tone Decay - Central or Peripheral:-

Through much is known about tone decay, there are many gaps in our knowledge of the phenomenon that are yet to be filled in. For instance, the question, whether the tone decay is a central or peripheral phenomenon has often plagued audiologists.

The wide range of etiologies that cause tone decay to be manifested, only adds to the conviction that tone decay is a complex process. Most studies implicate the

8th nerve as the locus of tonedecay, but other factors point to higher centres in the auditory system.

Peripheral factors in Tone Decay:-

Sorensen observed a per stimulatory and post-stimulatory depression of the activity of the VIII nerve after low intensity stimulation. Harbert and Young observed that abnormally rapid threshold tone decay was related primarily to lesions affecting dendrites and slower decay was related to widespread, partial damage to axons.

They thus hypothesize that threshold tone decay results from ionic changes in interstitial fluids affecting conductivity of dendrites.

This hypothesis may be further explained in terms of the critical off time. Jerger and Jerger found that in patients with VIII nerve pathology, for an interrupted tone, the threshold is sharply dependent on the off - time. As the critical off time is decreased, the results became indistinguishable from the indicated 'threshold' for a continuous tone. Jerger and Jerger relate this to a specific and apparently critical rest period between successive stimuli. This rest period between successive stimuli may be called the refractory period; A polarized neuron, excited fires a series of impulses, once it has fired, a neuron is depolarized so that it returns to its resting stage (The firing of the neuron changes the chemical environment in and around the neuron making it no longer polarized).

Once the neuron is depolarized, it reaches a state of exhaustion called the refractory period. The refractory period may be differentia-ted into two stages.

1. Absolute Refractory Period:-

During this the nerve cannot be excited since there is an exchange of ions in and out of the cell and

2. Relative Refractory Period:-

During which the cell membrane goes back to its resting state and the neuron is capable of being excited but only with intense stimulation.

Lesions affecting the dendrite or the 8th nerve would naturally affect the refractory period. Kupperman (1971) hold that adaptation results from the hyper polarization of the nerve fibre membrane.

Central Factors in Tone Decay:-

Yet experimental evidence points to other factors which wholly or partly influence tone decay.

Hernandez-Peon et al demonstrated marked adaptation in the electrical potentials recorded from the more central pathways i.e, the Dorsal cochlear nucleus.

Galambos(1951) and Pfalz(1964) showed that the efferent cochlear bundle controls the input coming from the ear, reducing it by varying amounts.

Leibrandt(1965) demonstrated that procaine hydrochloride when injected into the internal acoustic meatus blocked the efferent bundle and this resulted in less adaptation.

Hahn and De Michelis(1960) investigated the length of time a tone at or near threshold intensity could be heard. They found that a simultaneous intermittent light markedly reduced the period of audibility. They concluded that Tone Decay is not exclusively a peripheral phenomenon. They suggested that Rasmussen's efferent tract plays an important role by inhibiting the VIII nerve, but do not state how it is activated by light.

They thus opine that the efferent neural system's influence on adaptation is unlikely. The effect of masking on tonedecay also implicates a central factor. With such scanty data, it is difficult to speculate where tone decay lies. Adding to the confusion is the wide variety of lesions that can manifest abnormal tonedecay, from the VIII nerve to the cerebellum to even the cortex.

Menche and Rupp (1969) found that there was a slight suggestion of tone decay in 4 out of 10 unilateral brain damaged persons at 2KHz. They attribute this to "poor perception" in the ear's contralateral to lesion.

The Need for Research:-

Marked tonedecay is not always manifested in the pathologies described. Johnson (1965) is thus of the opinion that while positive tone decay indicates a strong probability of retrocochlear pathology, absence doesn't always rule out the possibilities of such a lesion. He found that 46% of 110 cases of surgically confirmed retrocochlear lesions had inconsistent results. He attributed this inconsistency to the differences in tumour size, but it indicates that our testsaare not sensitive enouth to indicate the site of lesion. Brand and Rosenberg (1963) believe that "bizarre findings" in cases of acoustic neuroma indicate "Weakness" in many of the tests and feel that in the diagnosis, a team approach was useful.

It has been found that Tone Decay is sensitive to procedural differences. Tests which employ long periods of sound stimulation like Carhart's Tone Decay test are reliable because they afford maximum opportunity to obtain positive results (Mencher and Rupp, 1969).

Obviously, our tests need to be modified, but this cannot be done without more knowledge as to the nature of Tone Decay.

Available evidence points to the fact that Tone Decay is governed by a complex process or a series of processes which may be situated at various levels in the auditory system.

In the last few years, practically no work has been done on this phenomenon and much investigation is needed so that we may have a more thorough knowledge about the locus and mechanism of Tone Decay.

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CHAPTER - III

METHODOLOGY

Equipment:-

A well calibrated Madsen OB 70 audiometer was used foe the purpose of recording tone decay at threshold level. The audiometer was calibrated for Both intensity and frequency as per ISO 1964 standards. The ear phones used were TDH - 39 in MX-41AR ear cushions.

An Omega stop watch was used to record the duration for which a tone was heard, Before it decayed into in-audibility.

METHOD:

Subjects;- Twenty two students of Speech Pathology and Audiology of whom 7 were males and 15 females were subjects for this study.

The subjects had to satisfy the following criteria:-

a) Pass a 20dB hearing screening test.

b) No history of any ear infections.

c) No family history of hearing loss, and

d) Fall within the age range of 16 to 25 years. The age of the subjects tested ranged from 17 to 23 years with a mean age of 19.95 years.

Procedure:-

Testing was done in a sound treated two room situation with noise levels conforming to the ISO 1964 standards. The subject was seated in an arm chair so that the control panel of the audiometer was out of his line of vision.

The subject was instructed as follows:-
"You will hear a tone in either your right or left ear. Rest your elbow on the arms of this chair, make a fist and raise your index finger when you hear. Even if you hear it softly, raise your finger, and hold it up as long as you heaar.

When you no longer hear it, bring your finger down; If you hear the tone in your left ear, lift your left finger and if you hear it in your right ear, lift your right finger." The instructions were accompanied by appropriate gestures.

Thresholds were established using the Hughson - Westlake procedure. The threshold was defined as the intensity level at which the subject responded to 3 of the 6 tone presentations.

The tone was initially presented at 40 dB HL and the intensity of the test tone was reduced in 10 dB steps following each positive response, until he failed to respond. The tone was then raised 5 dB. If the subject heard this increment, the tone was reduced 10 dB and raised in 5 dB steps until it was heard again.

At this stage, the vernier scale was used for greater accuracy as follows. A 2 dB decrement was used until the subject failed to respond, when a 1 dB increment was used until he heard..

After the thresholds were established, the subjects was instructed for the test task.

"I will present a tone in your right or left ear continuously. When you hear it, raise your finger and hold it up as long as you hear. Rest your elbow on the arm of this chair; if you feel there is a decrease in loudness, lower the level of your hand. When you feel that you no longer hear it, drop your finger."

As before, the instructions were accompanied by appropriate gestures and were repeated if necessary. The subjects were also told to indicate to the tester if they felt tired.

The tone was presented at threshold level. The duration of response was measured with the stop watch and recorded. It the subject continued to respond beyond 10 minutes, the presentation of the tone was terminated. When a decrease in loudness was indicated the time which elapsed from the onset of the stimulus to that point was noted down.

This method differed from the standard method used to measure concomitant monaural adaptation or tone decay, as developed by Carhart(1957) in three respects.

(1) The tone was presented at threshold level instead of at a level below the threshold.

(2) The duration for which the tone was heard at threshold, Before it decayed completely was recorded, but the intensity level was not raised.

(3) The subject was asked to indicate if there was a decrease in loudness.

One ear was tested at a time. The ear tested first was not constant across subjects. If the right ear was tested first in one subject, then the left ear was tested first in the next subject.

The frequencies tested were 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz and 8000 Hz.

Testing was continued unless the subject indicated that he was tired, or if the test extended beyond 40 minutes. A 3 minutes rest period was given Before testing recommended. At the end of the experiment, subjects were asked if they had noticed a change in tonality any time. Their responses to this question were noted.

The data collected so was statistically treated and analysed using appropriate statistical measures.

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C H A P T E R - IV

RESULTS AND DISCUSSIONS

This study was undertaken to find out the duration for which a tone was heard before it decayed into in-audibility. The hypothesis, examined was "The duration for which a tone is heard at threshold is independent of its frequency".

The study was performed on 44 normal ears of 22 young adults in an age range of 17 to 23 years with normal hearing, at frequencies 500 Hz, 1000 Hz, 2000 Hz, 4OOO Hz and 8000 Hz. The vernier dial was used to obtain greater accuracy in obtaining the thresholds.

The tone was presented at threshold level, continuously and without any interruption and the duration for which it was heard was recorded.

The results of the present investigation were statistically treated. The statistical means (M) of the puretone thresholds and the durations of decay at individual test frequencies were computed.

To find the variability within the group the standard deviation (S.D) and the range of duration (R) were computed separately at each test frequency.

The mean, S.D.. and range of the duration of decay at each frequency was also computed separately, for each ear.

4.1

Figure I shows the distribution of the durations of decay of 44 ears at each frequency.

Figure II compares the number of ear which heard the tone for durations upto 600 seconds at different frequencies.

Figure III compares the ear differences in the durations of decay at 500 Hz.

Table A:

Depicts the range, mean and standard deviation of threshold at each frequency for Right and Left ears.

	Right Ear			Left Ear		
Frequency	Mean	Range	S.D	Mean	Range	S.D.
500Hz	8	-4 - 20	7.4	10	-3 - 20	5.7
1000Hz	6	-3 - 20	6.8	8	-5 - 20	7.3
2000HZ	7	-7 - 18	6.8	5	-2 - 18	6.2
4000HZ	8	-4 - 20	7.5	8	-10 - 20	6.8
8000HZ	7	-5 - 20	8.7	3	-15 - 20	8

Table A depicts the Mean (M), S.D. and range of thresholds of each ear. The mean threshold did not vary much across the frequencies and between the ears. The S.Ds also did not differ significantly.

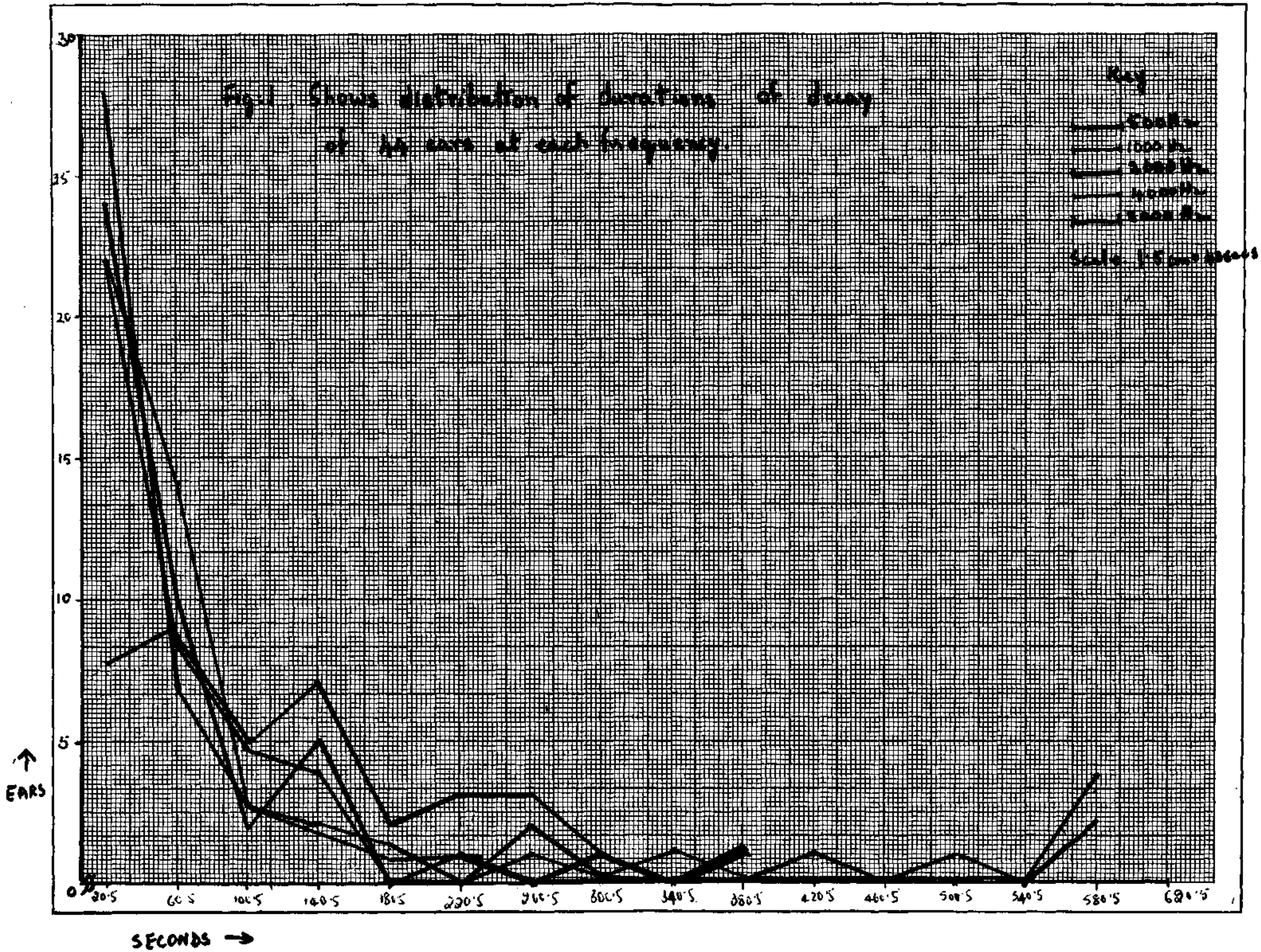
Fig. 1 Shows distribution of durations of decay
of 44 ears at each frequency.
Key
30
25
20
15
10
5
0
EARS
20·5
60·5
100·5
140·5
180·5
220·5
260·5
300·5
340·5
380·5
420·5
460·5
500·5
540·5
580·5
620·5
SECONDS

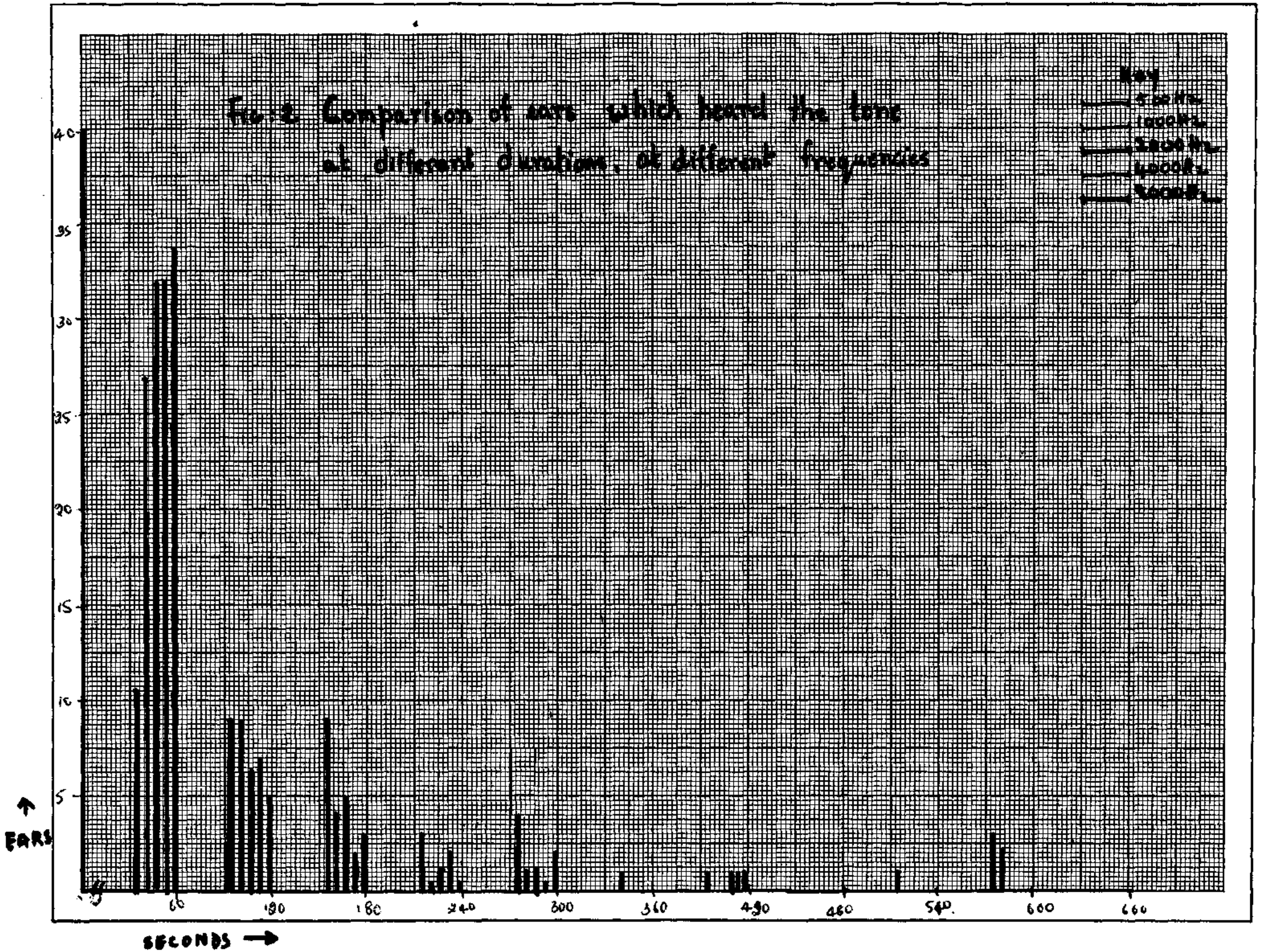

Fig: 2 Comparison of ears which heard the tone at different duration, at different frequencies

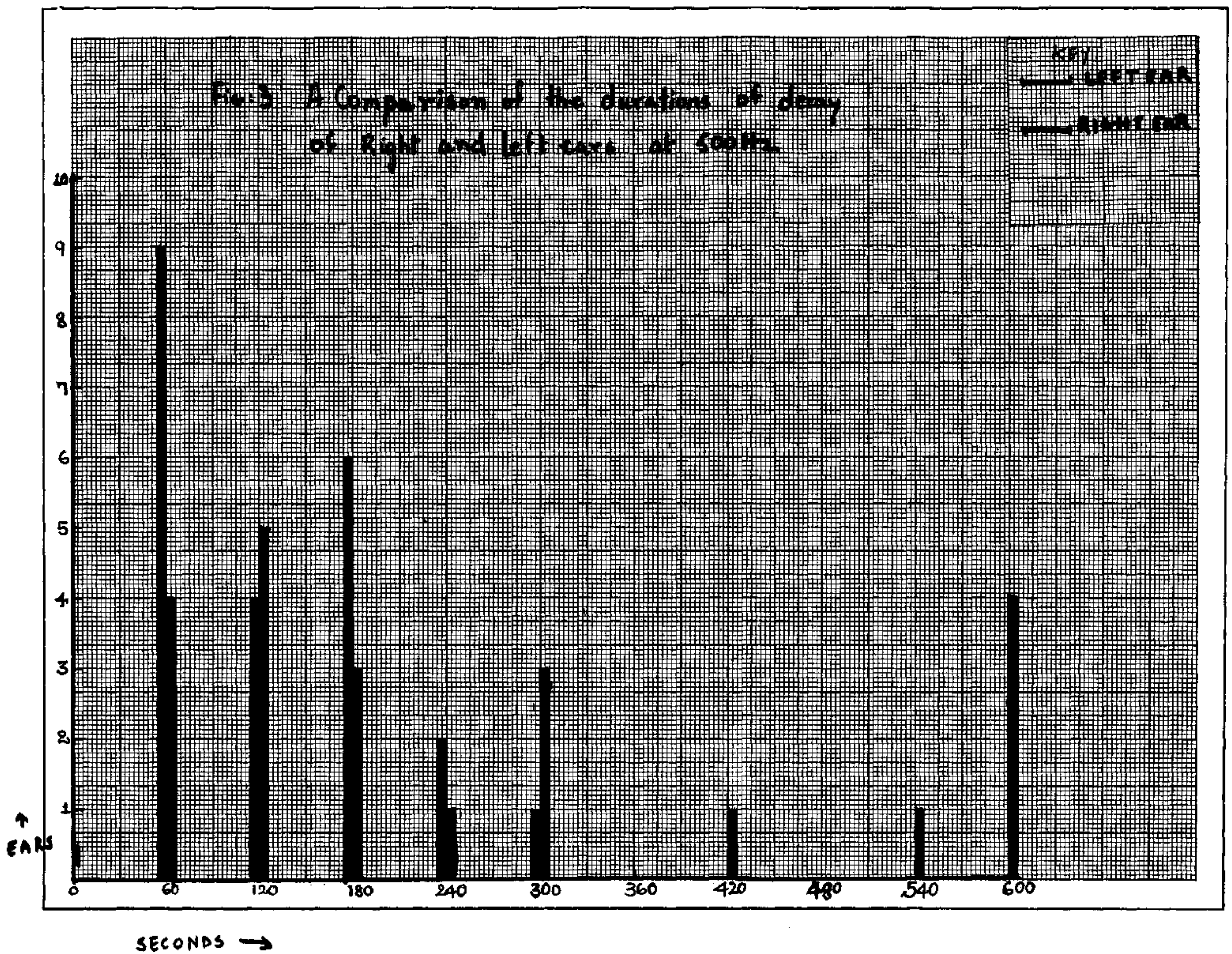
Fig. 3 A Comparison of the durations of decay of Right and left ears at 500Hz.
KEY
LEFT EAR
RIGHT EAR
EARS
SECONDS
0
60
120
180
240
300
360
420
480
540
600
1
2
3
4
5
6
7
8
9
10

The range at 500 Hz was -4 to 20 dB; at l000 Hz it was -5 to 20 dB,, at 2000 Hz -7 to 18 dB; at 4000 Hz -10 to 20 dB, at 8000 Hz -15 to 20 dB.

The range across frequencies is fairly constant except at 4000 Hz and 8000 Hz where it is -10 to 20 and -15 to 20 respectively for both ears.

The mean thresholds of Right ear for the frequencies 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz and 8000 Hz was 8, 6, 7, 8, 7 in dBs respectively and for left ear were 10, 8, 5, 8, 3 dBs respectively.

Thus, it may be said that the thresholds of the two ears did not differ significantly, nor was the variance between the two ears different significantly.

Table B depicts the mean duration of decay in seconds for each frequency, for the right, left and right + left ears. The S.D for each frequency was computed as well as the range.

At 500 Hz, the duration of decay ranged from 9 - 600 seconds. The mean for the (R + L) condition was 171.3 seconds, and the S.D. was 168.

At l000 Hz the duration ranged from 4 - 578 seconds the mean (M) was 87.9 seconds and the S.D. was 130.2. At 2000 Hz, the range was 5 to 368, the mean 63.11 seconds and the S-D. 74.7.

Table-B

Depicts the mean duration of decay int seconds, at each frequency, as well as the Range and S.D for Right, Left and Right + Left ears.

Frequency	Right			Left			Right + Left		
	Mean	Range	S.D	Mean	Range	S.D.	Mean	Range	S.D
500Hz	101.1	11-253	70.8	241.1	9.600	197.4	171.3	9*600	168
lOOOHz	67.59	4-330	80.76	108.23	10-578	96	87.9	4-578	130.2
2OOOHZ	65.77	6-368	90	58.45	5-155	49.2	63.112	5-368	74.7
4OOOHZ	49.5	8-238	51.6	68.5	9-38O	82.2	59	8-380	69
8OOOHZ	54.91	6-373	44.58	58.27	4-260	72	56.6	4-373	99

At 4000 Hz the range was 8 - 380 and the mean 59 seconds and the S.D. - 69.

At 8000 Hz, the range was 4 to 373 and the mean 56.6 seconds and S.D. - 99.

It can be seen that at 500 Hz both the upper limit of the range (600 seconds) and the lower limit (9 secs) were greater than the limits at all other frequency, ie. the least time for which the 500 Hz tone was heard was greater than the least durations at other frequencies.

There appears, also a tendency for the duration of decay to decrease with increase in frequency.

To find out the frequency effect, the data was treated with the Wilcoxon's Matched Pairs signed Rank test. The frequency pairs so trested were 500 Hz to 1000 Hz; 1000 Hz to 2000 Hz; 2000 Hz to 4000 Hz; 4000 Hz to 8000 Hz; The Wilcoxon's test was used because of the large standard deviation. The results obtained after analysis are tabulated in Table C.

Table-C:-

Results after analysis of duration of decay of different frequency pairs using Welcoxons Matched pairs signed rank test.

Frequency pairs compared	Obtained Values of T	Critical values of T at .01 level of confidence
500Hz - l000Hz	197	261 (N = 43)
l000Hz - 2000HZ	338	261 (N = 43)
2000HZ - 4000HZ	442.5	276 (N = 44)
4000HZ - 8000HZ	428	247 (N = 42)

When 500 Hz was compared with l000 Hz, the 500 Hz tone was heard for a longer duration. The T value obtained after treating it with the Wilcoxon's Matched Pairs Signed Rank test was 197. (The T value denotes the smaller sum of ranks associated with differences that are all of the same sign).

This value is less than the value 261 shown in the table at the .0l level of significance. Thus, the difference between durations for decay at the frequencies 500 Hz - 1000 Hz is significant, with 500 Hz tone being beard for a longer time.

When the 1000 Hz - 2000 Hz pair was treated statistically, the obtained T value 338 was greater than the critical value 261 at the .01 level of significance and was not significant at any other level. Thus the differences between the durations of audibility at the frequencies 1000 Hz and 2000 Hz were not significant statistically.

Similarly the differences between the durations of decay in the 2000 Hz - 4000 Hz pair were not significant at any level. The T value obtained was 442.5 and the critical value 276 at .01 level of significants, and, the T value obtained after treating the 4000 Hz - 8000 Hz pair was 428. The critical value was 266 at .021evel of significance.

Thus, it may be said there was a tendency of a decrease in duration of decay with increasing frequency. The differences are significant between 500 Hz and other frequencies; but above 1000 Hz, the differences are not statistically significant.

These results are in agreement with other studies. Morales-Garcia and Hood (1972) found in the normal hearing group of 41 ears, no tone decay was measurable at the test frequency 500HZ (only 7 ears were tested at this frequency).

At the test frequency 1000 Hz,10 of 41 ears had a slight threshold drift of 5dB? At 2OOO Hz, 10 of 41 ears had 5dB shift, and 2 had 10dB shift; at 4KHz, 10 of 40 ears had 5dB shift, 4 had 10 dB shift and 3 had 15 dB shift.

They also found that the magnitude of tonedecay varies with frequency and increased with frequency. Doehring and Swisher (1971) also found a relationship of tone decay to frequency when they tested 114 subjects with no evidence of retrocochlear pathology. They found that tone decay was smaller for 500 Hz at hearing threshold levels below 6OdB and then increased to the level of other frequencies above 70dB. There was no difference between 2000Hz and 4000 Hz at any threshold level.

Figure II compares the number of ears which heard the tone for durations upto 60, 120, 180,.........600 secs at different frequencies.

Inspection of this figure reveals that at 500 Hz, only 13 of 44 ears, was the decay present within a minute,. This may be compared to other frequencies. At 1000 Hz in 27 of 44 ears the tone decayed within 60 seconds, at 2000Hz it was 32 ears, so also at 40OO Hz and 34 ears at 8000 Hz.

At 500 Hz, 9 ears continued hearing between 61 to 120 seconds, at 1000 Hz, 2000 Hz, 4000 Hz and 8000 Hz 9, 4, 7, and 5 ears continued to hear between 61 seconds to 120 seconds. The number of ears which were able to sustain the sensation of hearing beyond 120 seconds and upto 180 seconds showed a further decrease. 8 ears at 500 Hz, 5 at 1000 Hz, 5 at 2000 Hz, 2 at 4000 Hz and 3 at 8000 Hz continued to hear the tone. As seen, the number of ears which continued to hear beyond 120 seconds were greatest at 500 Hz.

The number of ears responding to the tone beyond 300 seconds continued to decrease. Only four subjects continued to hear the 500 Hz tone upto 600 seconds at which point the tone was terminated. Besides at 500 Hz, at no frequency did a subject continue to respond upto 600 seconds except at 1000 Hz where one subject responded upto 600 seconds and one subject for 578 seconds.

Even in this dispersion or variability in the durations, a frequency effect is seen. This variability is also seen in the S.D.S at various frequencies. The S.D. at 500 Hz is 168 and is largest. The S.D.. tends to decreases with increasing frequency (Table B) upto 4000 Hz. At 8000 Hz, there is again a slight increase, but this is again lower than the S.D.s at 5000 Hz and 1000 Hz.

Thus, the null hypothesis -
"The duration for which a tona is heard at threshold is independent of its frequency."- may be rejected. This is in agreement with other studies (Morales-Garcia and Hood, 1972, Doehring and Swisher 1971) which obtained

the decay in terms of dB not seconds.

Decrease in loudness:

The additional factors investigated was the factor of loudness decrease. Only 9 subjects reported a decrease in loudness of the test tone.

At 500 Hz in 12 of 18 ears there was a loudness decrease at 1000 Hz, in 9; at 2000 Hz in 12, at 4000 Hz in 9, and at 8000 Hz in 12. Not all subjects reported a loudness decrease in all frequencies. A few reported a decrease in only one frequency.

It can be thus said that decrease in loudness is not always seen. Most of the times, the tone apparently becomes inaudible without a decrease in loudness (in this study as observed by the investigator).

Tonality Change:-

Only 4 subjects reported a change in tonality of the test signals. They reported that the lower frequencies seemed to merge with body sound towards the end.

Ear Difference:-

It was noticed that the data seemed to differ in the two ears. This is evident in table B and Figure III. For eg. At 500 Hz, the Mean duration of decay in the Right ear is 101.6 seconds and in the left is 241,1 seconds.

The range in the Right ear is 11 - 253 seconds and in the left ear is 9 – 600 seconds. This difference in the ranges is reflected in the S.Ds. The S.D at 500 Hz in the right ear is 70.8 and in the left is 197.4. Analysis of variance was computed to find out if this difference was significant.

It was found that the differences in Variance between the two ears for a given frequency were significant, statistically. The results are tabulated in Table D.

Table-D.

It gives the critical and obtained T values of the ear differences.

Frequency	Obtained value	Critical value
500Hz	7.79	2.38(at 0.01 level of significance
1000Hz	4.77	2.88(at 0.01 level of significance
2000Hz	3.25	2.88
4000HZ	2.28	2.09(0.05 level of significance)
8000HZ	2.62	2.09(0.05 level of significance)

The Wilcoxon's Matched pairs signed rank test was again used to find out if the difference between the ears for a given frequency was statistically significant.

At 500Hz the obtained T value was 60., at l000Hz it was 112, at 2000Hz, it was 100.5, at 4000Hz, 59, at 8000Hz it was 111.5, all of which were greater than the critical value of T = 48 for N-22 at the 0.01 level of significance.

Thus, the differences between the ears were not statistically significant in terms of the duration for decay.

The differences in variance between the ears are significant. This is due to the greater dispersion in the left ear.

The S.D. in the left ear was greater than the S.D. in the right ear for the duration for decay at a given frequency at all frequencies except 2000 Hz. At 2000 Hz, the S.D in the right was greater (90) as compared to the S.D of the left ear (49.2).

Two reasons can be given for this difference :-

a) The sample was not large enough,
b) A central factor is present. The dominance of the right hemisphere in processing non speech stimuli and may thus cause the tone to be sustained for a longer duration.

Davis and Weiler (1978) found an ear difference in auditory adaptation when they used the monaural simultaneous heterophonic balance method. A 500Hz adapting tone was used. They found that the average adaptation for right ear was 12.88 dB, S.D - 5.64 and for left ear, the adaptation was 4.2 dB and S.D - 4.52dB.

This difference was significant and the authors feel that the two ears must be treated independently. While it is dangerous to equate two different aspects of adaptation, it is possible that the differences in S.Ds are due to a similar mechanism.

Ruhm (1971) found that EEG responses recordings from homologous sites over the two cerebral hemispheres eluci-dated differential handling of sensory information by the two sides of the brain.

The stimuli were clicks presented monaurally. The majority of the subjects exhibited larger amplitudes from the right hemispheres, regardless of whether the signal was to the right or left ear, which was interpretted as laterality in favour of the right hemisphere. The inconsistencies observed when the stimulation was to the right ear was attributed to a possible interaction of laterality with a contralateral effect. The possibility of a central factor cannot be ruled out as is seen from the evidence of Hahn and De Michelis(1960). Furthers research is needed.

Thus, when a tone is presented to the ear at threshold levels continuously and without interruptions, the duration for which it is heard is frequency related. The 500 Hz tone is heard for a longer duration and this duration differs from the durations for decay at other frequencies significantly.

Above 1000 Hz the frequency effect is not statistically significant.

The variability between the ears for the durations of decay was not significant; however, the S.Ds differed significantly suggesting that there may be ear differences present. Further research is needed to clarrify this matter.

Only six out of 22 subjects reported a decrease in the perceived loudness and 4 reported tonality change, before the tone became inaudible.

CHAPTER - V

SUMMARY & CONCLUSIONS

It is well known that a tone presented at threshold continuously and without any interruptions cannot be sustained indefinetly. After a while, the tone decays into inaudibility. This phenomenon which appears as a tendency of the threshold to rise is Albrechts effect. Though tone decay is measured with a number of tests, there is no information available here about the length of time for which a tone is heard at threshold.

This pilot study, attempted to,
(a) Find the durations of audibility and (b) Find out if there was any frequency effect. So that normative data could be found.

The method used was a modified form of the Carhart's threshold tone decay test. Twenty two young adults with normal hearing were tested. The age range was 17-23 years with a mean of 19-95 years. Both the ears were tested, one at a time, continuously, unless the subject indicated that he was tired or the testing continued beyond 40 minutes. A rest of 3 minutes was given before testing was recommenced.

The frequencies tested were 500Hz, l000Hz, 2000Hz, 4000Hz and 8000Hz.

The hypothesis examined was "The duration for which a tone is heard at threshold level is indipendent of its frequency".

The mean, range and S.Ds were found at each ear for the thresholds as well as durations of audibility at each frequency.

The thresholds did not vary much across frequency, but the durations of decay decreased with increasing frequency. The Wilcoxon's Matched pairs signed Rank test was used to find out the significance of difference between the durations of decay. It was found that 500Hz tone was heard longest and when compared with l000Hz the difference was significant at 0.01 level of significance. Above lOOOHz there was no significant frequency effect. Thus the hypothesis was rejected. This finding is in agreement with previous studies conducted on similar lines, but with the amount of decay expressed interms of dB. Other findings include a slight ear difference in the durations of decay that was not significant at 0.01 level of confidence.

The S.D. of the durations of decay for the two ears differed significantly from one another for a given frequency.

16 this was not due to the small sample size it was hypothesised that a central factor plays a role.

Other findings were that 9 subjects reported a decrease in loudness at one or other frequency and 4 reported a tonality change just before a tone because inaudible. This was observed in low frequency tones and subjects reported that the tone seemed to merge with body sounds.

Further research is needed before any definite conclusion can be drawn.

Suggestions for further research.

(a) Replication on larger samples.

(b) Using a larger number of frequencies

(c) Using different stimuli.

(d) Treating ears independently to see the effect.

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