A COMPARITIVE STUDY OF THRESHOLDS FOR PURE TONES NARROW BAND NOISE AND WARBLE TONE IN NORMAL HEARING ADULTS

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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 - 570006

TO

Anna

And

Amma

CERTIFICATE

This is to certify that the independent project entitled:

"A COMPARITIVE STUDY OF THRESHOLDS FOR
PURE TONES NARROW BAND NOISE AND
WARBLE TONE IN NORMAL HEARING ADULTS"

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

Director,

ALL INDIA INSTITUTE OF SPEECH AND HEARING

Mysore - 570006

CERTIFICATE

This is to certify that the independent project entitled:

"A COMPARITIVE STUDY OF THRESHOLDS FOR PURE TONES NARROW BAND NOISE AND WARBLE TOME IN NORMAL HEARING ADULTS"

has been prepared under my guidance and supervision.

(GUIDE)

D E C L A R A T I O N

This independent project entitled

"A COMPARITIVE STUDY OF THRESHOLDS FOR
PURE TONES NARROW BAND NOISE AND
WARBLE TONE IN NORMAL HEARING ADULTS"

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 - 570006, and has not been submitted at any University for any other Diploma and Degree.

MYSORE

DATED: Register No.

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CONTENTS

Chapter - I

INTRODUCTION

In reviewing the evaluation of tests of hearing capacity, we find that in the early days of hearing testing the major aim was merely to discover if the individual had a hearing loss. Tests like Whisper, the clicking of coins, the ticking of a watch or the observation of reactions to the environmental sounds were in use. In a limited way these tests served their purpose but they did not offer the diagnostician the information that was specific enough to plan any type of therapy program.

With the introduction of tuning forks into the clinical testing many otologists included Weber, Rinne, & Schwabach tests into the routine testing which offered a rough approximation of the nature of the hearing loss. Concurrent with the development of these tests came the development of other testing devices like Politzer Acoumeter, Galton Whistle, Monochord, Tonometer, Kornings tuned cylinders, Bizold forks. But none of these provided satisfactory control of the intensity of the stimulus tone, and the testing was always done in sound field.

In 1876 Bell's invention of telephone made it possible to deliver the output directly into the ear, so with the introduction of the earphone and a means of controlling the intensity of the stimulus, the development of the puretone audiometer become feasible.

One of the first attempts to develop a pure tone audiometer was made by Hartmann in 1878. In 1879 Hughes introduced a unit that was given the name 'Audiometer'. The first binaural receiver appeared with an audiometer developed by Jacobson in 1885. In 1859 Seashore developed an audiometer which allowed for variation in intensity.

According to Knudsen (1931) the first pure-tone audiometer was developed by Dean and Bunch in co-operation with Seashore in 1919.

In 1921 Guttman introduced an audiometer with vacuum tubes. In 1924, Knudsen and Jonas presented an audiometer which had provisions for AC and BC testings.

Audiometxic testing techniques have taken many years to develop through trial and error and through experimentation. The principal objective of pure tone audiometry is to determine the sensitivity of the human auditory system.

Any sound no matter how complex, can be shown to be a combination of various tones. This is true even for speech. A frequency analysis of speech reveals that the greatest concentration of acoustic energy are between 300 Hz and 3OOO Hz although some frequencies above and below this range carry some information. Thus if an audiologist measures a patients ability to hear pure tones in the frequency range of 125 Hz through 8000 Hz, he has definite bases for predicting whether the patients hearing loss for speech is normal or impaired. The test signal is usually a pure tone. But pure tone stimuli have been refered to as 'meaningless and/or abstract' and therefore ofr questionable validity in testing. Low frequency tones (250 Hz and below) are to be easily masked by environmental noises and body noises. The higher frequencies are(2kHz & above) occasionally confused with tinnitus (Lloyd L.L and Young, 1969).

Pure tone audiometry is a discrete or fixed frequency audiometry where tone will be given in octave or semi octave steps. One assumption behind the use of octave or semi octave steps in discrete frequency audiometry is such that each frequency serves only to sample acuity at all intermediate frequencies. But the sampling may not be thorough especially with octave steps when considerable details can be lost if acuity at intermediate frequencies exhibit sharp disparity.

It is possible to obtain better sampling of acuity in a frequency region if instead of presenting a single tone selected from the middle of that region, one presents a hand of noise taken directly from that region. Narrow band noise have been used to determine threshold sensitivity in several recent studies. A NBN can he defined in terms of 3 characteristics. i. centre frequency, ii. band width and iii. filter slope (some times refered to as rejection rate). Centre frequency is commonly the octave test frequency. The band width of a NBN is defined as the points intersected by plotting a horizontal line 3dB below the peak frequency in the noise band. Filter slope is expressed in dBs/octave above and below the centre frequency. The task of attending to NBN stimuli are considered to be easier than to pure tone, stimuli (Sanders W.J., and Josef F 1970). Measured thresholds have been found to correlate highly and reliably with pure tone thresholds (Matkin and Murphy, 1970, Sanders and Josef 1970, Harford and Dodds 1971) and with SRT (Zarooff 1958).

A warble tone has been preferred as an alternative test stimulus to pure tone by several authors. Sivan and White suggested a psychological advantage to warble tones in that they reduced fatigue and uncertainity of the listener. Hardy (1958) indicated that a warble tone was a good attention centering device when used for testing children. Again Langenbeck (1965) indicated that a 'fluid character' was added by warble tones which excites the child's attention and keeps it awake. Finally Bender (1967) indicated that children often tend to respond more readily to a warble tone. The warble tone in contrast to a NBN examines a range as wide as its frequency deviation. Thus a warble tone with a center of 2kHz and a frequency deviation of * 5% would sample only the frequency range from 1900 to 2100 Hz.

It would therefore present less risk of invalidity in estimating the pure tone threshold. NBN on the other hand may elicit a response well outside the band width of the signal resulting in an inaccurate estimate of pure tone sensitivity.

Statement of the problem:-

"A comparative study of thresholds for pure tones, NBN and Warble Tones in normals".

The following hypothesis is proposed to verify in this study:

1. There is no significant difference between thresholds for pure tones and Narrow band noise.

2. There is no significant difference between thresholds for pure tones and warble tones.

Purpose of the study:-

The purpose of this study was to find out whether any significant difference existed between thresholds obtained with pure tone, narrow band noise and warble tone stimuli in normals.

The instrument used in the present study is a Maico diagnostic audiometer model MA22. The stimuli included for getting thresholds are pure tones and warble tones with frequencies from 250 Hz to 8kHz totally 10 frequencies and NBN centered around these frequencies.

In the present study 40 normal subjects in whom no impairment is found by otoscopic examination were tested.

Constructs used in the study:-

Normal ear:-

The ear with no apparent abnormalities revealed either by history or by ENT examination and with the hearing sensitivity below 20 dB (ANSI 1969).

Pure tone:-

Pure toneis a sound produced by an instantaneous sound pressure which is a simple sinusoidal function of time.

Warble Tone:-

Warble tone is a pure tone stimuli which is frequency modulated.

Narrow Band Noise:-

It is white noise in restricted frequency bands produced by selective filtering.

Threshold:-

It is the least audible SPL often defined as the Level of a sound at which it can be heard by an individual 50 % of the time.

Sound Pressure Level (SPL):-

Sound pressure level is an expression of pressure of the sound with reference to 0.0002 dyne/cm^2.

Limitations of the study:-

1. The sample selected for this study excluded children

and clinical population.

2. The audiometer consisted of hearing level ranging from -10 to 110 dB HL for both pure tone and warble tone but for NBN it was from 0 - l05dB HL.

3. Age range of the subjects were limited.

4. Done with limited number of subjects.

5. Different warbling tone levels could not be considered for testing as the audiometer provided only for 5% warbling.

Implications of the study:-

1. The warble tone can be substituted in the place of pure tone for testing as there is no significant difference between the thresholds for these two.

2. It has been stated elsewhere (Newby, 1972) that patients with tinnitus can easily perceive the warble tones than the pure tones. Hence while testing we can imply that we can use warble tone as an alternative for pure tone as there are no significant differences in thresholds for these stimuli.

3. While using narrow band noise in place of pure tone a clinician should apply appropriate corrections to bring in thresholds of narrow band noise to the level of pure tone thresholds. Because, the narrow band

noise thresholds are always better than those of the pure tones.

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Chapter - II

REVIEW OF LITERATURE

The principal objective of pure tone audiometry is to determine the sensitivity of the human auditory system. From a more technical point methods used for the assessment of thresholds may differ from one instrument to another depending upon individual constructional details.

The earliest detailed description of pure tone audiometric technique was provided in 1943 by Bunch. Hughson & Westlake (1944) recommended a standardized sett of procedures by presenting initially, a reasonably loud signal. In 1945, the American academy of opthalmology and Otolaryngology published a second syllabus on audiometric procedures. This publication edited by Newhart and Reger (1945) provided a bracketing method to find the pure tone thresholds. A threshold finding method that employs an initial ascending approach was described by Watson and Tolan in 1949.

A comprehensive description of psycho physical procedures in audiometry and the effects of these procedures have upon audiometric thresholds was provided by Hirsh in 1952. He suggested that testing starts with a 1000 Hz tone and that tones of lower or higher frequencies be tested after the thresholds is obtained for 1000 Hz.

The test signal is usually a pure tone. But pure tone stimuli have been referred to as meaningless and / or abstract and therefore of queationable validity in tasting. Low frequency tones (250 Hz and below) are told to be easily masked by environmental noises and body noises. The higher frequencies (2kHz and above) are occasionally confused with tinnitus (Lloyd L.L. and Young E.C. 1969).

Pure tone audiometry is a discrete or fixed frequency audiometry where tone will be given in octave or semi octaves steps: But if the sampling is not thorough we nay loose considerable details of acuity at intermediate frequencies exhibit sharp disparity. It is possible to obtain better sampling acuity in a frequency region if instead of presenting a single tone selected from the middle of that region, one presents a band of noise taken directly from that region. Acuity for the band of noise could be assumed to represent a sort of average of the acuities for all seperate frequencies contained with in the band as it might better summate the acuities in that frequency region. Thus a noise band around the dip might provide a better measure of the patient's ability to handle auditory cues in that frequency region, (Cecil K. Myers, 1957).

The use of pure tone audiometry can be avoided altogether because of 1. the intensity erratic nature of the standing waves in the earphone, ear drum coupling and the dependency of the standing wave pattern upon frequency, 2. the sharp irregularities at the higher frequencies of the ear-phone's frequency response curve and 3. the dependence on frequency of the impedance for which the ear-phone is used. So narrow band of noise and tones modulated perhaps 2.5% in frequency have been suggested as substitutes for pure tones by J.Donald Harris 1963, among others. For a variety of applications as frequency modulated or warble tones and noise bands do not produce standing waves they can be introduced into a sound field for threshold testing with difficult to test patients (Sanders and Josef 1970), or for evaluation of hearing aid gain and frequency response (Gengel et al 1971, Garstecki and Bode 1976).

A few investigators have compared narrow band noise and pure tone thresholds with either hard of hearing adults or hard of hearing children, as subjects. The earliest of these studies was that of Myers (1957) who concluded that the 2 signals were inter-changable at low frequencies but tended to differ at higher frequencies. Later Simon and Northern (1966) found that adults with normal hearing showed no significant differences between narrow band noise and pure tone thresholds while sensori neural hearing impaired adults had more sensitive thresholds when tested with narrow band noise. Gorstecki CD. and Daniel's study

(1976) explored the relationship between NBN thresholds obtained under conditions with normal listeners and with subjects demonstrating sensori neural impairment. They found that pure tone thresholds were 2-3dB better than thresholds for noise bands having about ± 20 dB/octave roll-off during monaural ear phone testing. Simon and Northern (1966) and Stephens and Rintlemann (1973) have indicated that audiometric configurations may influence puce tone and NBN agreement. In both investigations with adults NBN thresholds were shown to be significantly more sensitive than pure tone thresholds in persons with sloping audiometric configurations.

For children Orchik and Mosher (1978) compared pure tone thresholds obtained with narrow band of noise having equivalent band widths but varying in filter slope. They reported that narrow band noise thresholds at 1000 Hz and 2000 Hz over-estimated pure tone threshold sensitivity by as much as 19 and 31 dB respectively. They also found that the sharper the filter slope the closer the agreement was to pure tone thresholds. In studies of hard of hearing children both Sanders and Josef (1970) and Gengel et al (1971) found that thresholds for these 2 types of stimuli were in acceptable clinical agreement for children with relatively flat audiograms. Josef and Sanders (1970) used narrow band noise stimuli to measure auditory sensitivity in normal hearing adults. Pre school hearing impaired children and pre-school M.R. children. The results with M.R group suggest the fact that the task of attending to narrow band noise stimuli is easier than pure tone testing task and is therefore applicable to a large population than is pure tone audiometry.

The use of conventional pure tone audiometric procedures with the young child has been limited, atleast in part, by the characteristics of the stimulus, whether the problem is the abstract and uninteresting in nature of the pure tone (Willford 1961, Miller & Polison 1964) of that,the task of attending to other stimuli such as noise and warble tone might be easier than the pure tone listening task (Sanders & Josef 1970) or that the pure tone rarely has meaning for the child (Meyerson 1956) there is general agreement that the pure tone stimulus is a limiting factor in isolating children with hearing problems (Downs 1956, Thompson & Thompson 1972). The warble tone in contrast to a narrow band noise examines a range as wide as its frequency deviation. Thus a warble tone with a center of 2kHz and a frequency deviation of $\pm$ 5% would sample, only the frequency range from 1900 to 2100 Hz. It would therefore present less risk of invalidity estimating the pure tone threshold. NBN on the other hand, may elicit a response well outside the bandwidth of the signal resulting in an accurate estimate of pure tone sensitivity.

A warble tone has been preferred as an alternative test stimulus to pure tone by several authors. Sivian and White (1933) suggested a psychological advantage to warble tones is that they reduced fatigue and uncertainity of the listener. Handy (1958) indicated that a warble tone was a good attention centering device when used for testing children. Again Langenbeck (1965) indicated a 'fluid character' was added by warble tones 'which excites the child's attention and keeps it awake'. Bender (1967) indicated that children often tend to respond more readily to a warble tone. In the literature warble tone stimuli has been frequently indicated as substitute for the pure tone stimuli. The warble tone has specifically been suggested for use with children (Reilly 1958, Langenbeck 1965, Bender 1967) for patients with tinnitus (Davis 1951, Langenbeck 1965, Alpiner 1968) and for testing in sound field conditions, (Sivian and White 1963, Reilly 1958). Some threshold comparisons have been made between warble tone and steady state pure tone in adults (Dallos and Tillman 1966, Young and Herbert 1970, Staab 1971, Dockum and Robinson 1975) and indicate only small difference.

Staab and Rintelmann (1972a) reported the results of a survey regarding stimulus parameters for warble tones available on commercial audiometers. Response to a questionnaire completed by 24 audiometer manufacturers in 9 countries revealed that only 25% provided the warble tone stimulus. The frequency deviations provided varied from ± .2% above the base frequency to ± 10 % around the base frequency modulation rates provided ranged from 2 to 10/sec. Hence considerable variability was found regarding stimulus parameters commercially available.

Recently investigators(Staab & Rintelmann 1972b, Rintelmann et al 1972) have explored the influence of varying warble tone stimulus parameters(frequency deviation & modulation ratio) on threshold and have found a close relationship between warble tone and pure tone thresholds for normal hearing subjects. Slightly more sensitive thresholds were obtained, however, with warble tone stimuli. Similar results were found for normal hearing adults by Dockum & Robinson (1975) and for normal hearing four-year-old children by Robinson & Vaughn (1976). Orchile and Rintelmann (1978) compared pure tone, warble tone & narrow band noise thresholds of young normal hearing children ranging in age from 3½ to 6½ years. Stephens & Rintelmann (1977) demonstrated that the audiometric configuration does not significantly affect the relationship between pure tones and warble tones but does affect the relationship between pure tones and narrow-band noise. Differences were apparent at high frequencies.

A systematic comparison of pure tone, warble tone and narrow band noise thresholds has not been reported in India.

The purpose of the study is to explore the relationship between thresholds for pure tones warble tones and narrow band noise for adults.

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Chapter - III

METHODOLOGY

The methodology of the present study comprises of the following steps:-

1. To establish thresholds for pure tone for frequencies ranging from 250Hz, 500Hz, 750Hz, l000Hz, 1500Hz, 2000Hz, 3000Hz, 4000Hz, 6000Hz and 8000Hz.

2. To establish thresholds for narrow band noise for frequencies ranging from 250Hz, 500Hz, 750Hz, l000Hz,1500Hz, 2000HZ, 3000HZ, 4000Hz, 6000Hz and 8000Hz.

3. To establish thresholds for warble tone for frequencies raning from 250Hz, 500HZ, 750Hz, l000Hz, 1500Hz, 2000Hz, 3000Hz, 4000HZ, 6000Hz and 8000HZ.

Subjects:-

40 subjects with an age range of 18 years were selected 20 of them were males and 20 were females. Subjects had no history of ear aches or any other complaint. All had normal ear structures otologically and normal hearing audiologically (with reference to ANSI 1969. Thresholds within 20dB).

Equipment and Test Environment:-

An advanced diagnostic audiometer (MA 22) with TDH 39 earphones placed in MX-41 AR cushions, was used for testing. This audiometer allows for the testing of 11 frequencies from 125Hz through 8000Hz, also has a hearing level ranging from -10 to 110 dBHL for pure tone and warble tone, -5 to 105 dBHL for narrow band noise.

Narrow Band Noise Specification : Filtered White noise(equal energy per cycle noise), Maximum level 105 dB EM, frequency setting dependent.

Warble tone Specification : Pure tone stimulus is warbled by ± 5% of test frequency at a 5Hz rate.

Testing was conducted in a sound treated two roomed situation.

Calibrations-

Calibration of the audiometer was maintained using Bruel & Kjaer calibration unit which consists of artificial ear B & K type 4152, SPL meter B & K type 2203, and octave filter set B & K type 1613 in a sound treated room.

Periodic checking was employed to keep the unit in calibration throughout the period of the study.

Stimulus:-

Stimuli consisted of pure tone, warble tone and narrow band noise with a center frequency of 250Hz, 500Hz, 750Hz, l000Hz, 1500HZ, 2000HZ, 3000HZ, 4000HZ, 6000HZ and 8000HZ.

Test Procedure:-

Subjects were first screened at 20dB with pure tone for their inclusion in the study.

The testing was done in three sessions with atleast 24 hours of interval between the sessions. In the first session pure tone thresholds were established, in the second session narrow band noise thresholds were established and in the third session warble tone thresholds were established.

Measurement of Pure tone Thresholds:-

During the first session thresholds for pure tone were established for the subjects. Hughson-Westlake (1944) procedure was used to establish thresholds as described by Carhart and Jerger (1959).

First a tone at 40dB was presented to the right ear. As the subject responded presentation level was decreased in l0dB steps until the stimulus became inaudible. Once the level of inaudibility reached, the level of the tone was increased in 5 dB steps, until a level where the subject percieved the stimulus 50% of the time. This level was considered as her/his threshold level.

Following instructions were given to the subjects:

"Now you are going to hear a series of tones one at a time for a short duration, first in right ear then in the left ear. When you hear the tone press this button and keep it pressed as long as you hear it. signal in this way even for the softest tone. When you no longer hear the tone release the button. Remember to press the button whenever you hear the tone. Are you clear?

During the second session thresholds for narrow band noise were established using Hughson-Westlake procedure which was mentioned earlier. Following instructions were given to the subject:

"Now you are going to hear different kinds of noises one at a time for a short duration first in the right ear then the left ear. When you hear the noise press this button and keep it pressed as long as you hear it".

During the third session thresholds for warble tone were established using the same procedure as mentioned earlier. Following instructions were given to the subject:

"Now you are going to hear warble or fluctuating tones one at a time for a short duration, first in right ear then in left ear. When you hear this warble tone press this button and keep it pressed as long as you hear it".

After instructing the subject, the stimulus - tone/ Narrow band noise/warble tone was presented at supra-threshold level (40 dB) for the purpose of familiarization.

Thresholds were established for the three stimulus for all the 10 test frequencies (250Hz to 8000Hz) and were noted down in the tabular column shown below:

Name: Age:

PURE TONE

Ear	250HZ	500Hz	750HZ	1KHz	1.5KHz	2kHz	3KHz	4KHz	6KHz	8KHz
R										
L										
NARROW BAND NOISE										
R										
L										
WARBLE TONE										
R										
L										

Test Retest Reliability:-

6 subjects out of the 40 subjects were selected randomly for test re-test reliability. After a month again thresholds were recorded for all the stimuli for all the 10 frequencies tested earlier.

Data was treated statistically for variance and significance.

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Chapter - IV

RESULTS AND DISCUSSION

The present study was undertaken to find the differences in thresholds of hearing for puretones, Narrow hand noise and warble tones. Thresholds were established using these three stimuli for ten test frequencies 250 Hz, 500 Hz, 750 Hz, 1000 Hz, 1500 Hz, 2000 Hz, 3000 Hz, 4000 Hz, 600O Hz and 8000 Hz.

The sample selected in the present study consisted totally of 40 normal hearing adults of whom 20 were males and 20 were females. The age range of the subjects varied from 18 to 30 years with mean age of 24 years.

The results of the present investigation were treated statistically using parametric statistics. The statistical means (M) of pure tone. Narrow band noise and warble tone thresholds at individual test frequencies were computed and are given in tables I, II, and III. The frequency distribution of these means at different frequencies are given in Figure I (a, b) and Figure II (c, d).

Figure I (a, b) and Figure II (c, d) clearly indicates, a) A difference of 5.61 dB between the average pure toneand narrow band noise thresholds for Right ear.
b) A difference of 5.80 dB between average pure tone and narrow band noise thresholds for left ear.
c) A difference of 0.84 dB between the average pure tone and warble tone thresholds for Right ear.

TABLE I

The Mean and Standard Deviations of Pure tone Thresholds at various test frequencies.

Frequency		Right Ear	Left Ear
250HZ	M SD	5.88 5.34	5.13 5.30
500HZ	M SD	5.38 6.16	5.13 5.31
750HZ	M SD	5.00 5.24	4.50 5.68
l000Hz	M SD	4.00 4.90	3.50 5.30
1500HZ	M SD	4.38 5.03	5.00 5.16
2000HZ	M SD	3.25 4.68	3.50 5.12
3000HZ	M SD	2.25 5.59	2.38 4.66
4000HZ	M SD	4.75 6.89	4.00 4.62
6000HZ	M SD	12.75 6.86	12.62 6.60
8000HZ	M SD	3.50 9.04	4.63 8.41

Rt. ear Mean Average = 5.11. S.D = 5.97

Lt. ear Mean Average = 5.03. S.D = 5.61

TABLE II

The Mean and Standard Deviations of narrow band noise Thresholds at various test frequencies.

Frequency		Right Ear	Left Ear
250HZ	$\bar{X}$	-4.00	-4.00
	SD	2.29	2.29
500Hz	$\bar{X}$	1.63	1.25
	SD	4.66	4.45
750HZ	$\bar{X}$	1.50	1.63
	SD	5.00	5.17
1000Hz	$\bar{X}$	-0.87	-1.38
	SD	4.73	4.18
1500HZ	$\bar{X}$	-3.13	-2.88
	SD	2.92	2.93
2000HZ	$\bar{X}$	-3.62	-4.00
	SD	2.23	2.00
3000HZ	$\bar{X}$	-3.13	-3.75
	SD	3.13	2.90
4000HZ	$\bar{X}$	-1.38	-2.00
	SD	3.84	3.68
6000HZ	$\bar{X}$	4.50	5.00
	SD	6.24	5.12
8000HZ	$\bar{X}$	1.50	1.63
	SD	4.26	4.55

Right ear Mean average = -0.50 S.D = 3.93

Left ear Mean average = -0.85 S.D = 3.80

TABLE III

The Mean and Standard Deviation for warble tone Thresholds at various test frequencies.

Frequency		Right Ear	Left Ear
250HZ	$\bar{X}$ SD	3.50 5.29	4.00 5.13
500HZ	$\bar{X}$ SD	4.63 6.03	4.25 5.19
750	$\bar{X}$ SD	3.50 4.46	2.88 4.73
l000Hz	$\bar{X}$ SD	1.75 4.39	2.63 4.99
1500HZ	$\bar{X}$ SD	3.25 4.71	3.25 4.61
2000HZ	$\bar{X}$ SD	1.75 4.26	2.50 5.12
3000HZ	$\bar{X}$ SD	1.63 4.66	1.37 4.33
4000Hz	$\bar{X}$ SD	3.38 6.06	2.25 4.24
6000Hz	$\bar{X}$ SD	11.25 6.76	10.63 6.35
8000HZ	$\bar{X}$ SD	5.63 7.61	6.25 7.94

Rt. ear Mean Average = 4.27 S.D = 4.95
Lt. ear Mean Average = 4.47 S.D = 5.26

Figure-I(a) Frequency distribution of mean thresholds of Pure tones and Narrow band noise at different test frequencies - Right Ear.

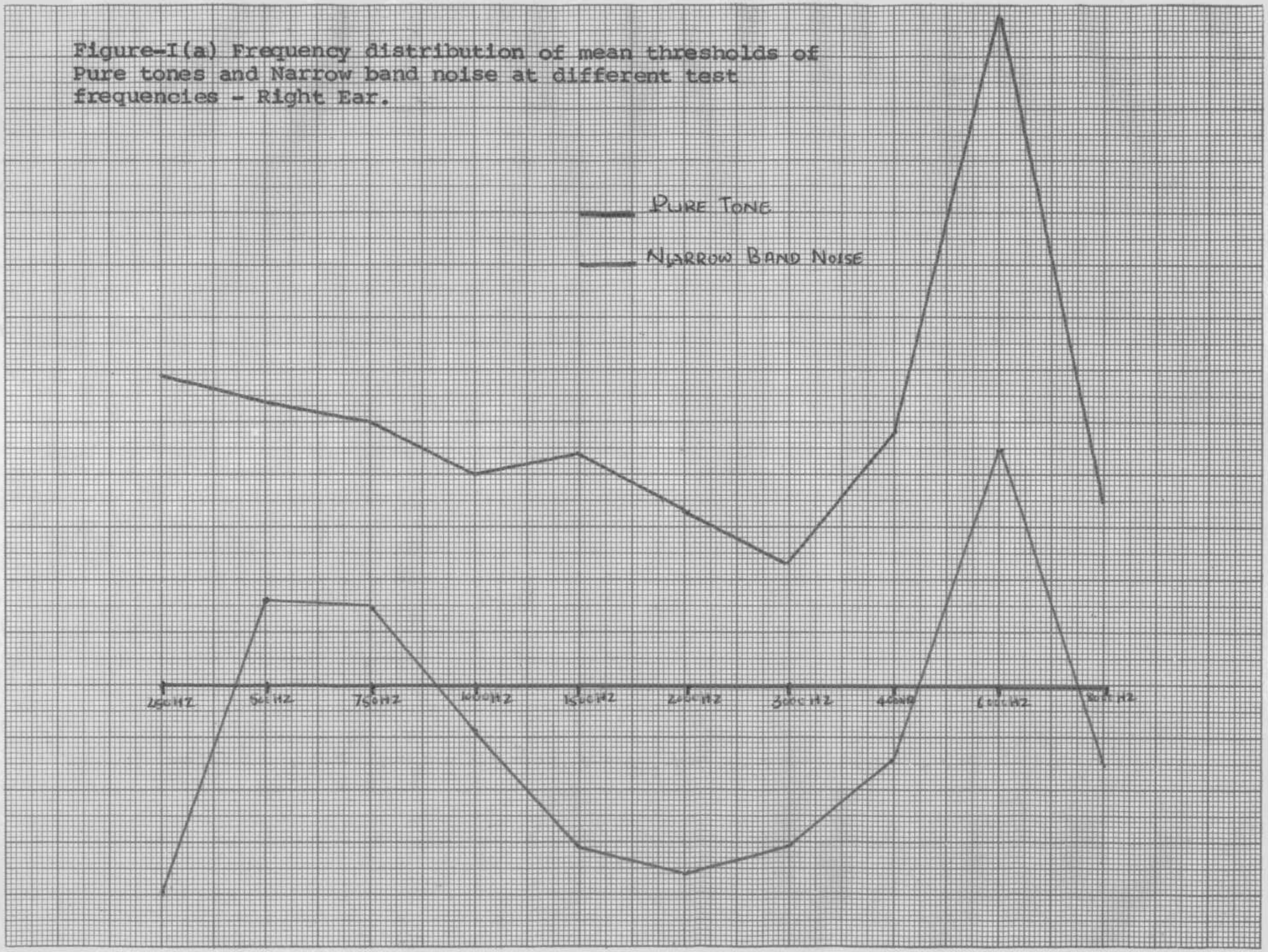


Figure-I(b) Frequency distribution of mean thresholds of Pure tones and Narrow band noise at different test frequencies - Left Ear.

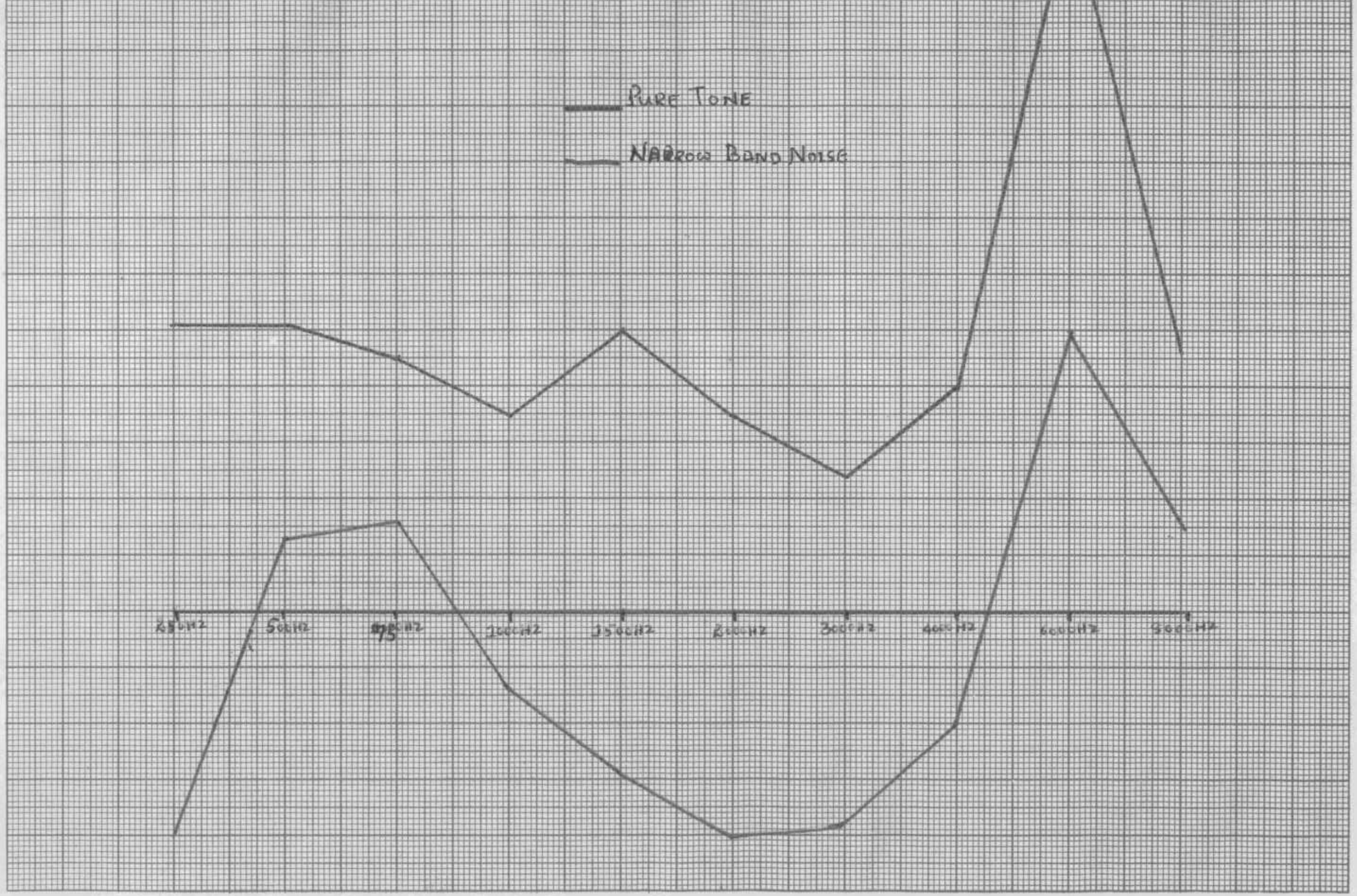


Figure-II(c) Frequency distribution of mean thresholds of Pure tones and Warble Tone at different test frequencies-Right Ear.

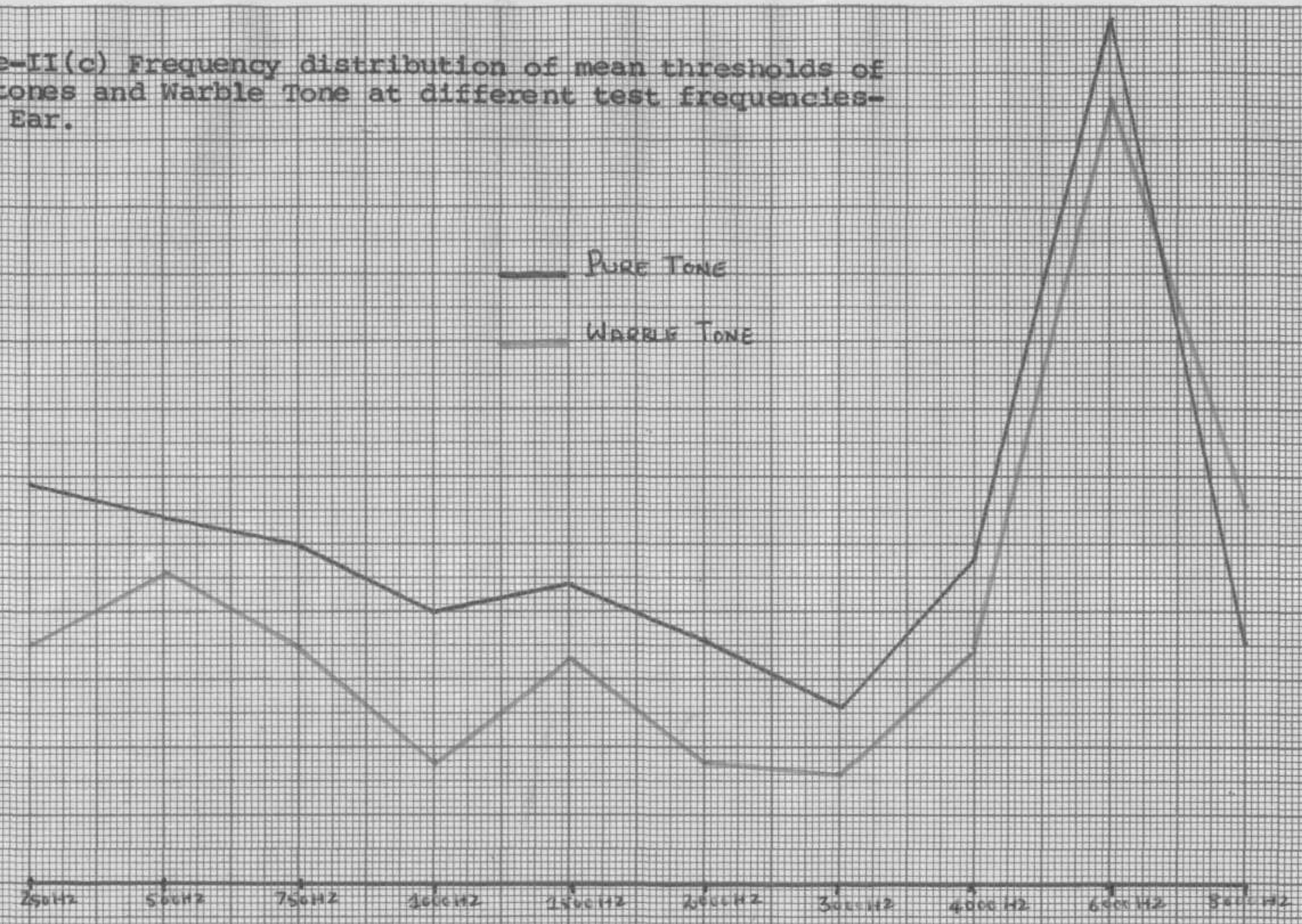
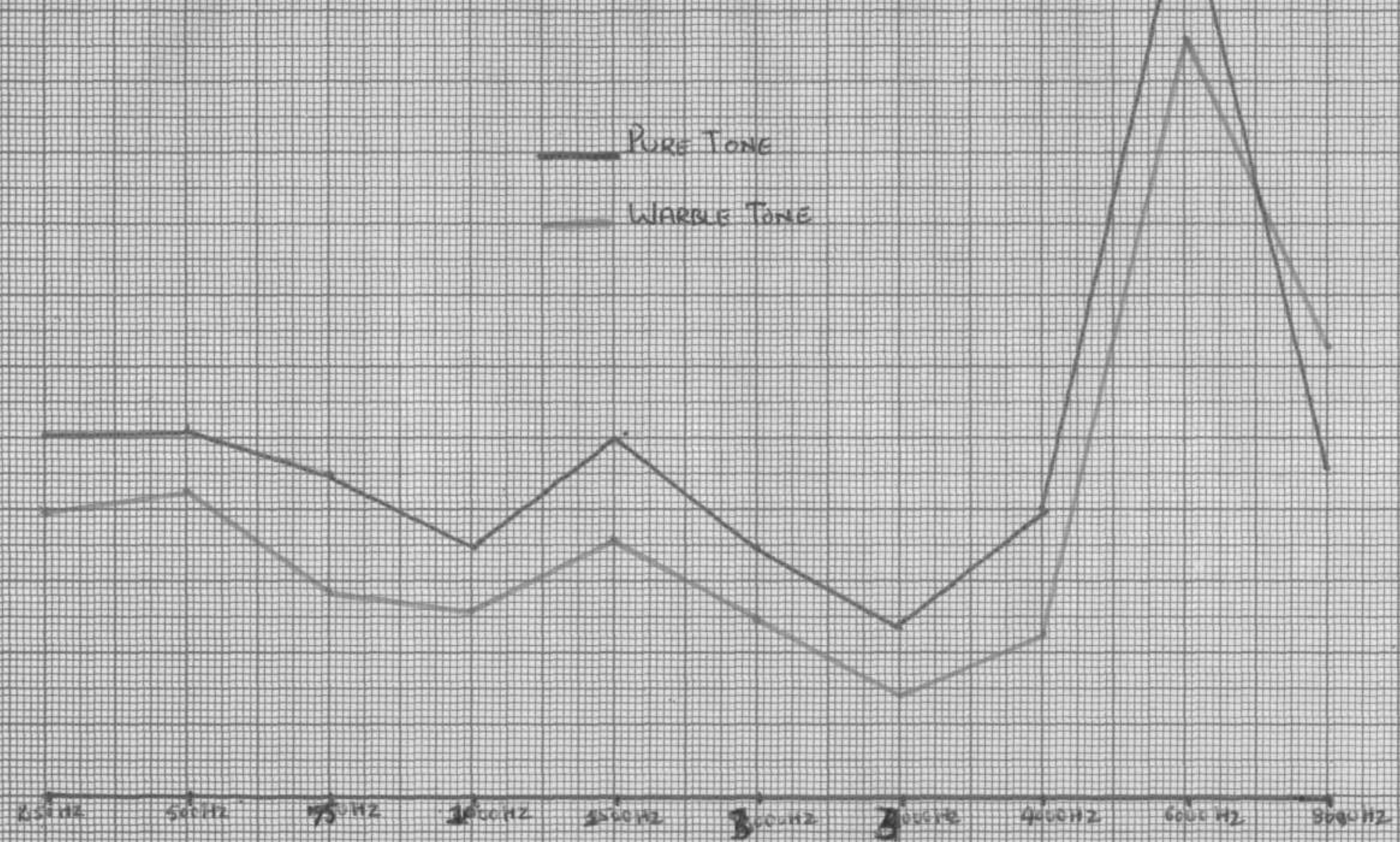


Figure-II(d) Frequency distribution of mean thresholds of Pure tones and Warble Tone at different test frequencies-Left ear.



d) A difference of 0.56 dB between the average pure tone and warble tone thresholds for left ear.

Tables I and II reveal that mean Narrow band noise thresholds are consistently better than pure tone thresholds at all frequencies. According to Table I and III mean warble tone thresholds are better than puretone thresholds except at 8000 Hz which is reversed.

To find the individual variability within the group, the standard deviation (SD) was compared at each test frequency for each stimulus and values are given in Tables I, II and III. The tables reveal that the variability is more for pure tone thresholds than for warble tone thresholds. However, the variability for warble tone thresholds are more than thresholds for narrow band noise.

2 trends were noticed in relation to standard deviation given in tables I, II and III

1. Standard deviation for narrow band noise and warble tone stimuli were consistently smaller than those for the puretone stimulus.

2. The magnitude of the standard deviation difference for all the three stimuli were quite small at any given test frequency.

In addition it is shown that the standard deviation value for both pure-tone and warble tone is greatest at 8000 Hz.

The difference method of "t" test was applied to assess the difference between thresholds of puretone, narrow band noise and warble tone.

The mean difference between puretone thresholds and Narrow band noise thresholds and their 't' values for each frequency are shown in the table IV and for that of pure tone thresholds and warble tone thresholds are given in the table V. Table IV reveals that the mean difference between thresholds of puretone and narrow band noise are significant at .05 and .0l level of confidence, while table V shows statistical significance at 4000 Hz and 6000 Hz between thresholds of puretone and warble tone.

Present study reveals that Narrow band noise thresholds are consistently better and are sensitive than puretone. This can be explained on the basis of "Group stimulation" (Langenbeck, 1965). Rhythmical stimulation of one hair cell alone is not sufficient to be perceived at the hearing center. The flow of stimulation produced is too weak and becomes absorbed in the course of its auditory pathway; A group of neighbouring hair cells must therefore be stimulated

TABLE IV

Mean difference of pure tone thresholds Vs Narrow-band noise thresholds and 't' value.

Frequency		Right Ear	Left Ear
250HZ	$\bar{X}$	8.5	8.50
	t	8.84	8.83
500HZ	$\bar{X}$	4.75	3.63
	t	6.00	7.30
750HZ	$\bar{X}$	2.75	2.63
		3.73	3.41
l000Hz	$\bar{X}$	4.37	4.00
	t	4.36	4.00
1500HZ	$\bar{X}$	8.38	7.38
	t	12.15	8.25
2000Hz	$\bar{X}$	6.87	7.15
	t	7.15	11.96
3000HZ	$\bar{X}$	7.13	5.75
	t	11.56	7.20
4000Hz	$\bar{X}$	5.75	6.25
		10.17	13.45
6000HZ	$\bar{X}$	7.63	8.50
		6.92	9.19
8000Hz	$\bar{X}$	6.63	5.87
	t	7.75	8.00

$\bar{X}$ = Mean difference

0.05 = 2.02

0.01 - 2.71.

TABLE V

The Mean difference of Pure tone thresholds Vs Warble tone thresholds and 't' value.

Frequency		Right Ear	Left Ear
250Hz	$\bar{X}$ t	0.13 0.01	0.63 0.69
500Hz	$\bar{X}$	0.50 1.50	0.50 1.50
750HZ	$\bar{X}$ t	0.50 0.75	0.75 1.00
l000Hz	$\bar{X}$ t	0.75 0.68	0.63 0.69
1600HZ	$\bar{X}$ t	1.13 1.16	1.63 1.66
2000HZ	$\bar{X}$ t	1.63 1.11	1.13 1.00
3000HZ	$\bar{X}$ t	2.25 1.25	1.00 0.40
4000HZ	$\bar{X}$ t	1.62 2.72	1.75 3.00
6000HZ	$\bar{X}$ t	1.88 1.89	2.13 2.56
8000HZ	$\bar{X}$ t	2.50 4.34	2.50 3.85

$\bar{X}$ = Mean difference.

0.05 = 2.02

0.0l = 2.71.

to produce flow of impulses sufficient to survive attenuation on the way to the center. This group stimulation will be achieved sooner by the noise than by Pure tone. Because stimulation with noise takes on wider basis. So because of summation, thresholds for noise is better than for pure tones. Jerger's (1974) critical band also explains that as the pure tones are confined to single band and as it gains loudness from several critical bands, it takes less intensity than the pure tone to elicit reflex.

Myers (1957) was one of the first persons to have compared Narrow band noise and Puretone thresholds and concluded that two signals were inter-changeable at low frequencies but tended to differ at higher frequencies. Simon and Northern (1966) found adults with normal hearing showed no significant differences between Narrow band noise and Puretone thresholds. In the study done by Stephens and Rintelmann (1973) they have indicated that audiometric configuration may influence puretone and Narrow hand noise agreement, and Narrow band noise thresholds were moresensitive than pure tone thresholds in persons with sloping audiometric configuration. As the 't' values obtained for the difference mean between puretone thresholds and Narrow band noise thresholds are significant, it clearly rejects the first hypothesis that "there is no significant difference between thresholds for Puretone and Narrow band noise." So if Narrow band noise is utilized as an alternative stimulus, this difference should be considered.

The results of the analysis show that 't' values obtained for the mean difference between thresholds for Puretone and Warble tone, are lower than the critical values at .05 and .01 levels of confidence, at 250 Hz, 500 Hz, 750 Hz, 1000 Hz, 1500 Hz, 2000 Hz and 3000 Hz, and indicating no significant difference. However, the 't' values were higher than the critical value at .05 level of Significance at 4000 Hz, 6000 Hz and 8000 Hz, indicating Significant difference. Hence the second hypothesis that there is no significant difference between Puretone thresholds and Warble tone thresholds was modified to state that "there is difference between Puretone thresholds at high frequencies at .05 level of confidence."

It is known that pure tones of higher frequencies are more difficult to elicit when compared to low frequencies. But Warble tone has got puretone modulations which makes the detection less difficult because as frequency increases band width also increases. So this might have resulted in better thresholds, which is causing significant differences at high frequencies.

A large variability was observed.

A large variability was observed interms of standard Deviation at 8000Hz (S.D = 9.04 for Right ear, S.D == 8.41 for left ear). This might be covering the significant difference between the thresholds for pure tone and Warble tone.

Staab (1971) reported that in general, Warble tones with frequency duration upto and including 10% and modulation rate as fast as 32 per second, resulted in close agreement of $\pm$ 5dB with Puretone thresholds. Dockum and Robinson (1975) did a study whose results substantiated Staab's (1971) results. They found significant difference between Puretone and Warble tone thresholds at 2000 Hz, 4000 Hz and 8000 Hz. They said as the mean difference for the test frequencies 250 Hz through 4000 Hz (0.07, 0.69, 0.21, 0.83, 1.39 respectively). did not appear large enough to result in 5 dB shifts. Eventhough large difference existed at 8 KHz because of their larger variability they said that difference might cause only 5 dB threshold shift, which do not significantly affect the slope of the audiogram. So they concluded that audiologist may use Warble tone with stimulus parameters equal to or less than utilized in their study, to measure thresholds that are directly comparable to puretone thresholds.

The results of the present study are similar to those of the above study(Dockums, Robinson 1975). The mean differences for frequencies 250Hz, 500Hz, 750 Hz, l000Hz, 3500HZ, 2000Hz, 3000HZ, 4000HZ, 6000Hz and 8000Hz did not appear large enough to result in a 5dB threshold shift. The 'mean of difference' of 2.5dB for both ears at 8000Hz represented the largest mean difference that was obtained. In view of its large variability only 5 dB threshold shift might occur, magnitude of which donot significantly affect the slope of the audiogram.

Thus we may accept the second hypothesis for that 'there is no significant difference between the thresholds for Pure tone and Warble tone', over-looking the modification that is stated earlier, that "there is a significant difference between thresholds for Puretone and Warble tone at high frequencies at 0.05 level of confidence"

In the literature Warble tone stimulus has been frequently indicated as a substitute for pure tone stimulus. It has been specially suggested to be used with children, (Reilly, 1958, Langenbeck, 1965, Bender, 1967), for patients with tinnitus (Davis 1951, Langenbeck 1965, Alpiner 1968) and for testing in sound field conditions (Sivian and White 1933, Reilly, 1958).

The testings of the present study are considered to be reliable because when 6 subjects of the original sample were randomly selected and retested after one month, yielded no significant difference in their thresholds for all the stimuli. The retest results are given in appendix, A, B, and C.

Test retest reliability is better for Narrow band noise stimulus. This might be because of the minimized influence of standing waves or due to smoothening of fluctuations from frequency to frequency of both acoustic impedance and frequency characteristics of earphones or might be due to the simpler identifications of the stimulus involving less learning, (Myers 1957).

The clinician who is employing narrow band noise audiometry for threshold measurements in chidren and other difficult to test patients should be aware of its limitations. 1. The clinician should know the parameters of Narrow band noise stimulus being used.
2. He/She should realize that band width and filter slope can result in a significant over estimate of threshold of sensitivity in patients with sloping audio-metric configurations. Finally, if a choice of alternative stimuli is available for threshold measurement (Warble tone and Narrow band noise) the clinician might do well to consider Warble tone as the stimulus of choice (Nancy and Orchik, 1975).

Warble tone examines a range only as wide as its frequency durations, so it presents less risk of invalidity estimating the puretone threshold. Narrow band noise on the other hand may elicit a response well outside the band width of the signal resulting in an inaccurate estimate of pure tone sensitivity.

As the present study did not include the behaviour of the clinical population and that of children, care must be taken when attempting to generalize the results of this study.

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Chapter - V

SUMMARY AND CONCLUSION

The purpose of the present study was to explore the relationship between pure tone, narrow band noise and warble tone thresholds (± 5% frequency deviation) for normal hearing adults.

A sample of 40 subjects with in an age range of 18 to 30 years was selected for the study. The data obtained were subjected to analysis to find out if there was any difference between pure tone and narrow band noise thresholds, and pure tone and warble tone thresholds at 250Hz, 500 Hz, 750 Hz, 1000 Hz, 1500 Hz, 2000 Hz, 3000 Hz, 4000 Hz, 6000 Hz and 8000 Hz. If the differences existed, their significance level was determined.

Thresholds for each stimulus was taken for all 10 frequencies. The mean difference of thresholds for pure tones and narrow band noise, mean difference of thresholds for pure tones and warble tones was found. Significant differences were found between thresholds of pure tone and narrow band noise, and thresholds between pute tone and warble tone at high frequencies (4000 Hz, 6000 Hz and 8000 Hz). The difference at 8KHz was attributed to the more variability. Eventhouth the difference was significant at 4000 Hz and 6000 Hz, the differences were not large enough to cause even 5dB shift. So it was considered that there is no significant difference between thresholds of pure tone and warble tone.

We hopefully believe that these two alternative test stimuli (narrow band noise and warble tone) would be increasingly be helpful in the evaluation of difficult to test patients.

Suggestions for future study:-

1. Comparison should be made for clinical population and children.

2. More number of subjects should be tested.

3. Effect of different warbling rates should be studied.

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APPENDIX - A

Correlation Co-efficient for Pure tone Thresholds

Frequency		Right Ear	Left Ear
250Hz	γ	0.95	0.51
500Hz	γ	0.78	0.65
750Hz	γ	0.53	0.94
1000Hz	γ	0.69	0.64
1500HZ	γ	1.00	0.60
2000HZ	γ	0.67	0.73
3000HZ	γ	0.91	0.80
4000HZ	γ	0.96	0.52
6000HZ	γ	0.78	0.89
8000HZ	γ	0.98	0.91

0.05 = 0.304

0.01 = 0.393

APPENDIX - B

Correlation Co-efficient for Narrow band noise thresholds

Frequency		Right Ear	Left Ear
250HZ	γ	0.43	1.00
500HZ	γ	0.60	1.00
750HZ	γ	0.80	0.50
1000HZ	γ	1.00	1.00
1500HZ	γ	1.00	1.00
2000HZ	γ	1.00	1.00
3000HZ	γ	1.00	1.00
4000HZ	γ	1.00	0.90
6000HZ	γ	0.60	0.80
8000HZ	γ	0.90	1.00

0.05 = 0.304

0.01 = 0.393

APPENDIX - C

Correlation co-efficient for Warble tone thresholds

Frequency		Right Ear	Left Ear
250HZ	γ	0.93	0.93
500Hz	γ	1.00	0.51
750HZ	γ	0.80	0.58
1000Hz	γ	0.57	1.00
1500HZ	γ	1.00	1.00
2000HZ	γ	1.00	1.00
3000HZ	γ	0.84	1.00
4000Hz	γ	1.00	0.51
6000HZ	γ	0.72	1.00
8000HZ	γ	0.94	0.79

0.05 = 0.304

0.01 = 0.393