A COMPARISON OF FREQUENCY DISCRIMINATION AMONG NORMALS AND DYSPHONICS

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A COMPARISON OF FREQUENCY DISCRIMINATION AMONG NORMALS AND DYSPHONICS

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CERTIFICATE

This is to certify that the dissertation entitled "A Comparison of Frequency Discrimination among normals and Dysphonics" is the bonafide work in part fulfillment for M.Sc. Speech and Hearing, carrying 100 marks of the student with Register No.____

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CERTIFICATE

This is to certify that the dissertation has been prepared under my supervision & guidance

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Lecture in Speech

Pathology

DECLARATION

This dissertation is the result of my own study undertaken under the guidance of Mr. N.P. Nataraja, Lecture in Speech Pathology, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier at any University for any other diploma or degree.

Mysore Reg.No. 25.

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

> "Once a sound begins to be uttered, the subject's acoustic monitoring of his own on-going vocal output – either directly or indirectly . . . . . .may lead to further find readjustments of the motor unit activity obtaining in the laryngeal and oropharyngeal musculature" (Wyke, 1974).

Fairbanks (1942), Judson and Weaver (1957) Van Riper (1963) Anderson (1961), Luchsinger and Arnold (1965, 1970), Hysak (1966) have stressed the importance of feedback in speech therapy and the inter-relationship between perception and production. It is Anderson's belief that once an individual is habituated to certain standards which do not match his culture norms he is either unwilling or unable to discriminate between his defective performance and acceptable sound production.

In voice therapy the patient is trained to use his optimum frequency. This training also involve, training the ear, so that, the patient would be able to detect changes in frequencies. This will help him to change his old voice towards the optimum by monitoring his vocal (frequency) production.

The smallest difference between two frequencies that the ear discriminates varies with reference to the frequency of the referent. This smallest difference is called difference limen.

e.g., below 1000 Hz, the ear can detect a difference of three cycles. That is an individual is capable of detecting 997/1003 Hz as different from 1000 Hz. Difference limen depends on frequency, duration of stimuli, sex, ‘musical’ and ‘non-musical’ type of ears, age, and several other factors.

Investigators have extended, this discriminative powers of the ear, to the study of speech defects and the hard of hearing.

Gengel (1969) recommends pitch discrimination training for the hard of hearing children in teaching inflectional and intonational patterns. Sommers (1961), Stinchfield (1928), Kuper (1972) have found a relationship between auditory discrimination and articulation.

A deficiency in discriminating between frequencies has been stated as one among the several causes of dysphonia and misarticulation (Fairbanks, 1942; West et al, 1957; Anderson, 1961; Van Riper, 1963). It is advocated by these authors and several others including Murphy (1964) Boone (1967) and Eisenson et al (1958) that auditory training, particularly, training in frequency discrimination be incorporated in the treatment of such patients.

“In voice therapy, we are concerned with making the patient a critical listener” (Boone, 1967).

There are only a few studies available, on frequency discrimination ability in dysphonics (Gilkinson 1943, Eisenson et al 1958; Boone et al 1967), eventhough poor frequency discrimination, has been cited as one of the possible causes of dysphonia.

There has been some diversity of opinion regarding frequency discrimination abilities in dysphonics, as compared to normals.

Gilkinson (1943) and Eisenson et al (1958) indicate a relationship between poor frequency discrimination and dysphonia, While Boone’s (1967) study indicates no such relationship, though he suggests that individuals dysphonics who have good frequency discrimination show better prognosis.

However, there seems to be an agreement on the need for ear training in voice therapy.

Eisenson et al (1958) measured frequency discrimination in their group of dysphonics, using the seashore measures of musical ability, before and after voice therapy and ear training. They found that the scores increased significantly after the training period.

Most authorities agree that musicians perform better in frequency discrimination task, compared to non-musicians, (Lagenback 1965, Madsen 1969, Hirsh, 1952).

Statement of the Problems

The problem was to device a suitable method to measure frequency discrimination and to compare this ability in normals and dysphonics in an Indian population. It was also intended to see if people trained in music would have better discrimination.

Method

Pairs of tones (one followed by another), differing only in frequency, were recorded and served as test material.

This was fed through, an earphone, worn by the subjects, who had to indicate, when he could make a difference between two tones of the pair. Subjects were divided into three groups, ie., dysphonics, normals, and people trained in music.

Hypotheses

The following, hypotheses were made:-

1. There is no difference between the dysphonic group and the normals, in their ability to discriminate frequencies.

2. There is no difference in frequency discrimination ability between the sexes.
3. Left and right ears perform equally well in frequency discrimination task.
4. There is no difference in frequency discrimination ability between, people trained in music, and those untrained.

Limitations

1. The frequencies selected for the discrimination task, were restricted to low frequencies only ranging from 100-500 Hz.
2. The investigation on pitch discrimination task, was not extended over various age groups.
3. The group of dysphonics tested consisted mainly, of functional voice disorders.

Definitions

The definitions used in the present study are: -

1. Dysphonic - An individual who diagnosed by a Speech Pathologist as having a voice problem.

2. Functional Dysphonic - A voice problem, with no apparent organic involvement.

3. People trained in music - Those who have undergone (atleast one year) formal training in music either vocal or instrumental.

CHAPTER II

REVIEW OF LITERATURE

"Good speech must be more than merely audible; it must be intelligible as well" (Gray and Wise 1959) adequate projection contributes to both these criteria.

Intonation and inflection are two more characteristics of speech that go hand in hand and help to make speech intelligible.

> "When pitch changes without interruption of phonation, the changes is termed an inflection. This aspect of pitch usage has been shown experimentally to be very closely related to the expression of meaning and emotion" (Fairbanks, 1940).

Patterns of inflectional changes constitute intonation. Each spoken language has its won intonation pattern. There are certain language called "Tone Languages" in which "Pitch is a very significant parameter as when compared to other languages". (Gleason 1966). In these language, variations in tone, connote variations in meaning. Pitch variation is also one of the ways of stressing a sound, syllable or word.

> "Good speech is both purposive and communicative; having agreeable voice quality, should be pitched at a level, which is best for that particular voice, highly flexible and have sufficient strength, and distinctly articulated, and finally semantically sound……." (Gray and Wise, 1959).

A combination of all these forms a style which is unique to each individual. Voice has been defined as – p = S.T by Fant (1966). Where P = Voice, S = Source, T = Transfer Function of vocal tract. In the present study this definition will be used. According to Eisenson (1967)normal voice should possess certain minimal characteristics of pitch, loudness and quality, which makes meaning clear, arouses the proper emotional responses and ensures a pleasant tonal effect upon the hearer.

According to West et al (1957), some of the criteria for a normal voice are, adequate loudness, clearness of tone, pitch appropriate to the age and sex, a slight vibrato, and a graceful and constant inflection of pitch and force, which follows the meaning of what is spoken. A normal voice does not call attention to itself. Most of these criteria however, tend to be subjective. Black (1942) stats that the normal voice is a matter of opinion of society.

The three basic attributes of voice are pitch loudness and quality. Pitch is the psychological correlate of frequency i.e., Pitch is the subjective auditory impression of the frequency of a sound; but “frequency of a tone does not uniquely determine it’s pitch” (Stevens and Davis 1938). Hence when specifying the pitch of a tone it is desirable to refer to the pitch of a tone at some standard level of loudness, the convenient standard being 40 decibels (Fletcher, 1934).

Michel and Wendahl (1971), state that: -

> "The first step in the study of voice, must be the determination of pertinent measurable parameters". They mean that changes in these variables should have a perceptible effect and should be "measurable in order to quantify and correlate the changes with the effects"

Though there is no definite one of one correlation between pitch and frequency, there is a correlation, in the sense, when frequency of tone is raised, the perceived pitch too seems to be raised. In normal hearing persons perceived pitch changes associated with variations in intensity are not very large; however, the directions of these slight changes depend on the frequency. As the intensity is raised, the pitch of the low tones (below 1000 Hz) becomes lower, while that of the high tones (above 4000 Hz) becomes higher (Glorig, 1965). The tonality or definiteness of pitch depends on the duration. A tone should last for an appreciable time, if it is to have a completely definite pitch. Subjective pitch according to Glorig (1965) is not clear unless the tone lasts for about a twentieth or a tenth of a second.

Although pitch is often defined in terms of a pure tone, it is clear that noises and other a periodic sounds, have more or less definite pitches. In general pitch of complex tones, according to Stevens and Davis (1938) "depends upon the frequency of its dominant component; the fundamental frequency in a complex tone is the one perceived" (Plomp, 1967) status that periodicity of pitch has been found to be important in perception of pitch in a complex tone. Even in complex tones, where the fundamental frequency is absent or weak, the ear is capable of perceiving the fundamental frequency.

Even though pitch has a correlation with frequency, it varies with the duration and the intensity of the tone.

The human larynx is capable of producing a wide range of frequencies. There are several studies regarding the maximum frequency range that the larynx can produce. Anderson (1942) reports that "the total range of the vocal mechanism . . . . . . including voices of both men and women extends almost four octaves from a low tone of 70 to 80 d.v. per second in male voice to upwards of 1,024 d.v. in female voice".

Luchsinger and Arnold (1965) state that the range is from 50 to 2000 Hz, the lowest bass and soprano taken into consideration. Hollien and Michel (1968) state that the mean range for model range for males was just over an octave and a half with frequency limits from 71 to 561 Hz, that of females being almost two octaves within a frequency range included the habitual frequency (often erroneously called habitual pitch) and is the one most frequently used in speech. Most of the studies on frequency range include the falsetto and vocal fry. Therefore they give a range much greater than the model frequency range.

However, falsetto is seldom used in speech though the vocal fry is used at the end of a sentence. In a study by Sammuel (1973) the fundamental frequency ranges for different age groups of Indians, ranging from 7 years to 25 years for both sexes, were reported. For males in the 7 year old group the fundamental frequency ranged from 200-300 Hz. In the 25 year old age group the fundamental frequency ranged from 100 – 160 Hz. For females, in the 7 year old age group, the fundamental frequency ranged from 230-350 Hz and in 25 year old age group the range was from 180 – 220 Hz.

Each individual used a particular frequency most frequently in his speech. This is termed as habitual frequency. “It is accepted that each person in accordance with his unique physical vocal equipment has a pitch level of which of greatest power an best resonance occurs under the conditions of greatest physio-acoustic economy” (Murphy, 1964). Several others (West et al; 1957, Perkins; 1971, Michel and Wendhal; 1971, Van Riper and Irwin; 1958, Thurman; 1958) are of the same opinion. This pitch level is known as the optimum or natural pitch level, and varies from individual to individual. There are several methods of locating the optimum pitch. Recently, Nataraja (1972) has developed a method of locating optimum frequency objectively. This optimum frequency makes use of the resonators to the maximum extent and thus gives maximum loudness. Loudness is the:

> “Psychological correlate of intensity. Voice is loud or soft depending upon its effects upon the auditory reception and perception of the hearer . . . . of the two tones, the one louder if the pitches are not too far apart. But there is no clear relationship between intensity and loudness, that there is between frequency and pitch” (Gray and Wise, 1959).

The three major determinants of intensity in the human voice are, strength and duration of breath pulse, duration and force of closure of glottis, and coupling factors in the resonators.

Loudness according to Black and Moore (1962), not only differentiates the inaudible from the audible, but distinguishes the animated from lifeless talking. One judges the loudness of a tone, chiefly by audibility of speech.

Timbre is the physical correlate of quality. It is determined by the combination of frequency and intensity. Michel and Wendahl (1971) state that, while loudness and pitch each has a principal psychical correlate and can be measured psychophysically, quality cannot be done so “due to the existence of many qualities each with its own underlying parameters”. Quality is mainly affected by the mode and rate of vocal cord vibrations, characteristics of resonators and also by the relative intensity levels of fundamental frequency and harmonics. The resonators determine the broad spectra of voice. Anderson (1961), states that one’s voice, does not have more quality than another, but simply a different quality. Both quality and loudness are mainly dependent upon the frequency of vibration

Hence it seems apparent that frequency is an important parameter of voice.

It has been reported that it would be possible to achieve maximum loudness with good quality by using optimum frequency. This frequency varies from individual to individual and thus there is no one frequency which is best for all individuals. This is also the conclusion of Thurman (1958), and Nataraja (1972).

Nataraja, further explains that this optimum pitch is perceived when the vocal cords vibrate at their optimum frequency.

In women the optimum frequency is higher than that of man.

Some individuals fail to use the optimum frequency that is best fro their particular vocal mechanism, due to reasons which may be organic or functional. The vocal disorders are frequently classified as pitch disorders, loudness disorders and quality disorders. Perkins (1957) states that these parameters are not separable and that they are highly interdependent. Voice production depends on the mode and rate of vibration of the vocal cords, psychological conditions and the shape and size of resonators; and a change in any of these factors will bring about a change in voice.

As stated by Mysak (1966), the importance of auditory monitoring of the voice is rather generally accepted”. Stromata

(1959), conducted an experiment to indicate that “Phonation as well as speech perse are affected or controlled by audition, concurrent to the activity”.

He further stated that “it is interesting to consider that certain speech problems may be due to aberration of the auditory control signal, which exceeds the limits of auditory control system”.

One of the most viable theories in speech and hearing science describes interaction between perception and production. Fairbanks (1954) applying cybernetics, to the speaking process, viewed speech as an example of automatic control, in which the acoustic output and the somesthetic feel of speech feedback for comparison with the intended output. He presented his concept in the form of a model rather than as a replica of the speaking system. Among the principles demonstrated in his model, is that of a closed cycle control i.e., any self regulating system that controls its own performance, to achieve a goal. In contrast, in the open cycle control, the goals are imposed from outside the system, rather than from within it. Another important principle described is the negative feedback, which is basic to correcting the performance of any homeostatic system. The following inferences have been drawn from this model.

1. To disrupt auditory, tactile or kinesthetic feedback, would be to disrupt speech output.
2. Set points on goals to guide sound production are established initially by open cycle control.

3. Once, set points, that match cultural norms are stabilized, future speech performance can be guided automatically by closed cycle control. Conversely, if the set points are not stabilized by an individual then he must be either unwilling or unable to discriminate between his defective performance and acceptable sound production. Applying this to voice disorders it can be said that "the subjective impression of one's own voice, must be broken down, before much can be accomplished in the way of developing a more adequate vocal response" (Anderson,. 1961)

A person who speaks a language with an accent, may not hear the differences between his speech and that of those who pronounce the words properly. This is a defect in his sense or use of hearing, to be sure, but it is one attributable to his lack of training, as are "the clumsy movements of an unskilled dancer! – not to the defect in him as human raw material" (Bergeijik et al 1958).

The importance of feedback has been stressed by many authors in speech and voice training programs. Tactual and proprioceptive feedback are the other common modalities, by which one gets some information while speaking. But it is the auditory feed back system, according to Boone (1967) by which one can actually monitor one's phonation.

One of the measures of the relative efficiency of an individuals auditory system is his ability to distinguished slight differences in frequency, intensity or complexity.

Bergijik et al (1958) Denes and Pinson (1973), state that for sounds of moderate level, one can detect a change of pitch of about 3 cps. for frequencies below 1000 Hz, and for higher frequencies, the minimum detectable differences is a constant fraction of the frequency amounting to about one semitone. The literature on the differential sensitivity for frequency with advancing age is still limited. However, it is established that hearing acuity decreases with advancing age. Corso (1967) states that hearing acuity of frequencies associated with the basal part of the cochlear becomes impaired (as presbycusis setz in) and as a result hearing acuity becomes poorer with advancing age. He has reported data on the hearing acuity for different frequencies in various age groups ranging from 18 – 65 years. From his experiments, he inferred that for men, the decrease in sensitivity to various frequencies starts from the age of 32 years and for women from 37 years. However, he states that after the onset, the hearing loss seen is more gradual but at a faster rate in women. In men the effect is discontinuous, occurring in steps of 15 years and it is slower. The frequency first affected being 4 KHz and later and lower frequencies, 250 Hz being affected last. Since hearing acuity deteriorates with age, it is probable that the Δf *becomes poorer. Lagenbeck states that from the age of about 50 years onwards increases especially for high frequencies, and usually it is earlier, than

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* Δf is the minimum detectable change in frequency

500/0 of the trails. The basic requirement of this method, is that the stimulus must be variable in small discrete steps of equal physical magnitude in ascending or descending order. The stimulus just detected by the observer, and if further decreased is not detected by the observer, is his absolute threshold.

The method of Constant Stimulus difference

As in the case of absolute threshold, there is a zone of transition, a range of uncertainty, associated with differential judgments. This range extends from difference between two stimuli, in which the greater stimulus is always judged to be greater. The DL is located within this range of uncertainty. Though the DL can be measured by a number of procedures, the method of constant stimulus differences is considered to be the most accurate of all psychophysical methods in this respect.

The basic procedure in determining the DL by the above method involve the presentation of a comparison stimulus (Sr) simultaneously with or in temporal sequence with a standard stimulus (Ss) and the task of the observer is to report, which member of the pair, appears to be ‘larger’ or ‘smaller’ than the other. Some times, ‘equal’ or ‘doubtful’ judgments are permitted the restriction of judgments of two categories is usually preferred.

The stimuli are usually selected from preliminary investigations. The number of comparison stimuli is fixed, after preliminary investigations and ordinarily ranges from four to seven. A comparison stimulus equal to the standard is often included and the final series of comparison stimuli represent a set of values that are systematically arranged around the standard stimulus in equal symmetrical steps. In a pitch discrimination experiment with a standard of 1000 Hz, 1002 Hz, 1004 Hz etc., The constant stimulus difference is 2 Hz.

The experimenter presenter simultaneously or successively a pair of stimuli consisting of the standard stimulus, and one of the comparison stimulus. On each trail, the same standard stimulus is used as a member of the pair. The observer’s task is to judge the second stimulus, as ‘larger’ or ‘smaller’, than the first, ‘if the members of the pairs are presented successively. And if presented simultaneously, the right or left member is always judged in comparison with the other.

The Method of Average Error

It is common place, that stimuli that are identical in their physical characteristics, are often judged as being different; likewise stimuli that are different physically are often judged as being the same, that is identical or equal, since the presence of apparently extraneous factors may interact in such a way as to affect the judgement under consideration.

Since the method of average error is employed to determine the subjective equivalence of 2 stimuli the observer is provided with a standard stimulus (Ss) and a comparison stimulus (SV). The comparison stimulus is continuously variable with respect to the attribute being judged. The adjustment of the SV, made by the observer, is his judgment of Ss as measured on the physical scale; each judgement therefore, provides a measure of the point of subjective equality (PSE).

The other two selected methods of psychophysical scaling discussed by Corso (1967) are the Ratio method of fractionation and the method of Direct Magnitude.

The Ratio Method of Fractionation

The fundamental assumption here is that, the observer is able to perceive and to indicate the magnitude of a sense ratio i.e., the ratio between two subjective magnitudes on a given psychological continuum. The task of the observer is to indicate, when the sensory magnitudes associated with two stimuli stand in a specified ratio. The task of the observed, is to adjust or to select the variable so that the resulting sensory magnitude provides a subjective ratio of the variable to the standard that is equal to the ratio prescribed by the experimenter e.g., the observer may be required to adjust the variable stimulus so that if appears to be one half of the standard. In the fractionation method there is no fixed number of standard stimuli that should be employed in the construction of a scale but a large number of standard stimuli is preferred with a maximum of 10 or so.

Method of Direct Magnitude Estimation

The usual procedure is one in which the experimenter selects a particular single stimulus, on a given physical continuum, and assigns a number to its subjective magnitude. The observer is then, presented in turn, with the members of a set of variable stimuli and is instructed to assign, to each variable stimulus, a number, (a decimal, a whole number, or faction), which seems to him to be proportional to its subjective magnitude as compared to the standard. The judgements are expressed in terms of subjective magnitudes and the psychophysical scale is therefore obtained directly.

A fairly recent method of stimulus presentation is the Glissando Technique (Sargeant and Harris, 1962), in which gradual transition from one frequency to the next is effected.

Experimentation using this method involves varying rates of glissando and different stimulus durations. Sensitivity to glissando seems to be good according to these investigators; the ear being most sensitive to 1 to 10 seconds duration glissando. Sensitivity tended to break up between 10-25 seconds duration glissandos.

Little correlation was found between pitch discrimination results as ascertained by glissando technique and by the method of constant stimuli, already mentioned. Judson and Weaver (1965)state that to determine the j.n.d.* of pitch (between two tones) on oscillator may be used “but often, however, matched tuning forks or a set of graduated forks are used because they are easily available”. Using matched forks, first, one is struck then the second. The pitch of the second fork is altered slightly by weighting one of the prongs. The listener reports whether the two tones, are the same or different. Then the difference is perceptible the two forks are sounded together and the number of beats difference in their frequency.

The AB and the ABX procedures are two methods of finding difference thresholds of frequency (Micheal Saslow, 1967). Saslow stats that it is often reported that the difference thresholds of frequency when measured by an ABX procedure, are atleast twice as great, as those measured by an AB procedure. The relationship has always been renationalized in terms of greater physical and judgmental complexity of the ABX procedure (Saslow 1967).

Saslow (1967) conducted experiment at 120 Hz, 70 dB SPL, with two practiced subjects. For frequency differences of $\pm$ 0.3 cps or 0.25%, responses were 95% correct for ABX and 82%

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*j.n.d. = Just noticeable Difference

correct for AB procedure. These results according to him, contradict the usual findings. The AB and ABX procedure, as classically executed, differed in two ways:-

1. Number of stimuli in each trial: In AB – two stimuli A and B; and in ABX -3 stimuli A,B and X.

2. Kind of response required: In AB procedure, “the second stimulus sounds higher/lower, in pitch, than the first”, In ABX, “the third stimuli is most like the first/second stimulus”.

The greater complexity of the ABX technique, is given as the reason for the poor results. Rosenblith and Stevens (1953) state that the ABX DL’s are usually double the size of the DL of AB technique. Harris (1952) states that “although the instruction to the subject, in ABX can be very simple, it is clear, that a really, very involved judgmental process is called for”. Saslow (1967) states:

> “the subjects is not making single judgment as good psychophysical practice usually requires, but a compound one; he firs has the opportunity to compare B with A, and probably always does make this comparison; then, he compares X with B; and he has to reach back in time, so to speak, and compare X with A; and finally he has to make his judgments of whether XB or XA comparison is the minimal”

In his experiment Saslow (1967) trained two subjects in both methods for two months. He concluded that the AB method had worsened, to be as bad as the ABX performance of 95% correct at 0.3 cps. His subjects were only to indicate, in the AB procedure if frequencies were low or high, hence LH or HL (high low) and in the ABX procedure responses may be HHL, LHH, HLH. He states that, this type of response will be less cumbersome, than having to say "the third stimulus is more like the second, than the first stimulus" etc.,

The conclusion is that the auditory system is capable of making good successive frequency discriminations and "just because a procedure involves, there, rather than two stimuli, on each trial it does not permit one to assume that there will be a performance decrement" (Saslow, 1967).

Swigart (1967) conducted an experiment where, in the first part of the experiment the subjects (music majors), were asked to determine, discrepencies between frequencies of pure tones, presented through either, Bone Oscillator, or earphones (Monaurally or binaurally, fundamental frequency of the vocal and limitations of pitches of pure tones. Vocalizations were recorded on a tape and analyzed to determine fundamental frequency.

In the second part of the experiment, pure tones were presented at one of two intensities, through a bone oscillator, placed on the mastoid bone, and matched in pitch with a pure tone, variable in frequency by the subject, presented through the earphones (monaurally and binaurally). Discrepancies of responses in hertz were recorded. Results indicated minimal differences among response to the stimuli, through bone oscillator and also monaurally and binaurally through earphones. However, an increase in intensity of the stimuli, through the bone oscillator, raised the matched frequency of pure tones, through the earphone and lowered the fundamental frequency of vocal limitation of those pitches.

Madsen (1969) reports that “the earliest experiments in this area (frequency discrimination) has been poorly recorded or uncontrolled”. He quotes, Delezenne (1827) who conducted one of the earliest experiments using vibrating string as his frequency generator and made his observations at 60 Hz. Further, Madsen (1969) in his review of studies on frequency discrimination states that Seabock, similarly recorded at 1029 Hz and Weber at 200 Hz. Gaps in the major portions of speech frequencies were filled in by Peyer (1876), Luft (1887), Meyer (1914) and Knudsen (1923), as reported by Madsen (1969). Madsen (1969)believes these early experiments were limited greatly by the lack of appropriate control lab equipment and their results were characterized by exceptionally small DL values.

In these studies, vibrating strings and tuning forks, as sound generators, were used and intensity was not accounted for, with the exception of Krudsen (1923) who retained a constant sensation level of 40 dB. This was the first experiment where electrically generated tones were used. His results were in good agreement with Vance’s (1914) as stated by Madsen (1969).

Stevens and Davis (1938), while discussing the studies on frequency discrimination state that shower and Biddulph’s (1931) investigation was through, in the sense, they covered the frequency range from 31 Hz to 11,700 Hz, at sensation levels ranging from 45 dB SL to the maximum level which the observer could tolerate at any given frequency. They also overcame the effects of harmonic and transient frequencies. The difference between the two frequencies were also controlled and the observed had to report when this difference was just large enough for the perception of variation in pitch. They concluded that for monaural listening, the relative DL’s are larger than for binaural listening and at low frequencies and low intensities DL’s were largest. Knock (1937), reports Madsen, criticized some of the methods used in prior studies (Knudsen; 1923) Shower and Biddulph (1931)and gave his own mathematical model. Madsen et al (1969) state that knock’s “abstract mathematical model of pitch sensitivity is not easily understood, nor perhaps relevant”.

Recently AER has been utilized specifically to investigate auditory discrimination at suprathreshold levels. Several investigators have reported AER’s to samlle changes infrequency or intensity of an ongoing pure tone (Jerger & Jerger, 1970; McCandless & Rose, 1970; Ruhm, 1970; Lenhardt, 1971).

Pitch discrimination depends on various factors. Some of the factors which affect the results of measurements, when a comparison of tones has to be made, as stated by Lagenbeck (1965) are:-

1. The way in which the frequency is altered
2. Whether the measurement value was attained by progressing from the below threshold or above threshold region.
3. The number of alterations of pitch/second
4. Monaural or binaural measurement
5. Air or bone conduction measurement
6. The duration of presentation
7. Fatigue by duration of test
8. The influence of practice
9. The human type and “musical ear”
10. Psychogenic factors

He further explained these factors by stating:

For 1 to 3 – The ear does not perceive a steady, very slow alteration of pitch. If the change of frequency is very rapid i.e., number of changes/second is large only a ‘whine’ is heard. In between lies the relatively flat optimum of pitch discrimination namely 3 changes/second depending upon intensity.

For 4 to 5 – measured monaurally and by bone conduction lies somewhat higher than values found on binaural and air conduction measures.

For 6 - A presentation time of 3 seconds is sufficient with 3 changes/second.

For 7 – In a long series of tests, no increase in was found in subjects with normal hearing.

For 8 – Practice Often decreases

For 9 – The musician differentiates pitch better than non-musical subjects.

If changes from one frequency to another occurs abruptly, clicks appear which are disturbing. The length of pauses between the two tones (preferably no pauses), the duration of the tone (1 – 2 seconds are sufficient), and the number of presentations affect the results of the measurements. In normal subjects, the absolute value of , increase with rising frequencies. The absolute values of in the medium loudness (intensities of 40 – 60 dB) show a flat optimum, and rise against with smaller and grater loudness. As for the source of the sound, Lagenbeck (1965) states that, “heterodyne oscillators or resistance capacitance generators are suitable.

Tape, Recorders are cheap and simple, the jumps in frequency are recorded on the magnetic tape without clicks”.

Much auditory research has been characterized by intensive investigations concerning frequency discrimination, intensity discrimination and duration discrimination.

Some researches (Harris; 1947, 1948, 1966, small; 1963, Henning; 1967) found that under homolateral stimulation by wide band noise, was a function of signal to noise ratio and does not show any difference between the quiet and masking conditions.

The in the presence of contralateral stimuli was investigated by Chocholla and Saulnier (1962) and Mandonia et al (1968). They reported that considerably increased when the simultaneous and continuous stimulation to the opposite ear was by a pure tone, whose frequency was alike or close to the one delivered to the test ear, but if the contralateral stimulus was different the effect was different, which they have not explained.

It has been hypothesized by studdert-Kennedy and Shankweiler (1970) Studdert-Kennedy, Shankweiler and Pisoni (1972) that purely auditory analysis of speech i.e., the transformation of acoustic waveform of speech into psychological dimensions of pitch, Loudness, quality and duration may be accomplished by the general auditory system, common to both hemispheres.

However, the left ear superiority, in recognition of melodic line of sung speech in a study by Bartholomeus (1974) and left ear superiority, in the recognition of emotional tone of spoken sentence (Haggard and Parkinson, 1971) might suggest that paralinguistic stage of speech processing is accomplished more efficiently by the right hemisphere. Bartholomeus (1974) states that “at the very least, these findings indicate, the need for further research on laterality effects during the auditory stage of speech processing”. Recently, Farley and Gundrum (1972) conducted a study of pitch discrimination in relation to personality variables of extraversion and neuroticism. They concluded that no significant correlation was found between these factors.

Lewis, Cowen and Fairbanks (1940) using short modulating sound pulses from an oscillator concluded that sensitivity to pitch, depends upon the rate and extent of modulation, whereas the duration of the modulation, did not appear to be a factor, and that perceived extend of pitch change, varies inversely with the rate of modulation.

Postman’s (1946) data, as reported by Hirsh (1952), on time error, indicate that although the interval between two successive tones is crucial, when they are compared with respect to loudness variations, by varying intensity, the comparison with respect to pitch, by varying frequency, is independent of the time interval.

Though Weber’s law explains intensity discrimination, Hirsh (1952) caution the use of Webers law in explanation frequency discrimination by stating that:

> "Perhaps one should not speak of Weber's law in connection with frequency discrimination, because it was formulated with respect to stimulus intensity. We cannot ignore the fact, however, that the relative DL for frequency remains constant at about .003 as the frequency is increased above 1000 Hz. This means that at 1000 Hz one can detect a change in frequency of about 3 cps and at 5000 Hz one cannot detect a change of less than 15 cps, just as in the case of intensity discrimination. So it the case of frequency discrimination, man seems to keep his ability, to discriminate stimuli on a relative basis".

Investigations on auditory discrimination, have been done on animals also. Dowson, Wertheim and Lynch (1968) conditioned six monkeys with positive reinforcement technique on a successive auditory discrimination task i.e., pressing of two levers A and B for the two stimuli, tone and noise. The animals required 1100 trials for acquisition. Tone and noise were given at equal intensities and equal durations (.5 seconds) with .5 second intervals. Retentions were measured after thirty days. It was found that 90% correct responses were emitted.

Frequency discrimination in goldfish was done by Fay (1970)using classically conditioned suppression of respiration response. Audiograms were first taken for frequencies 30 to 2400 Hz. DL's were then determined by the same method at 50, 100, 200, 600, 800 and 1000 Hz. All stimuli were presented at 35 dB sensation level. The frequency DL's increased from 3.5 cycles at 50 Hz to 47 cycles at 1 KHz. They concluded that, although man, in order of magnitude, is more sensitive, the DL's for both man, and fish are 'two power functions or frequency and the DL slopes of the goldfish are identical to the DL slopes of man.

Hohl (1967) as quoted by Herman et al (1972) found, in an experiment on common seal that the overall discrimination was considerably poor, but a constant relative DL of approximately .013 was observed for the frequency range of 1 – 57 Hz.

Arbeit’s (1972) investigations on Bottle-nose dolphins, where 8 frequencies were used (1–70 Hz), indicated that exceptionally fine frequency discrimination capacity were seen between 6 – 50 Hz. The relative DL ranged from .002 to .003. These experiments on animals were done using intricate instruments and rigorous conditioning procedures.

Research on complex sound discrimination, in the hearing impaired, have been reported. Measurements of frequency discriminations for simplified speech-like sounds, namely a single resonant peak (or formant in a harmonic spectrum) were made (Pickett and Martony, 1968). The frequency location of the formant was controlled automatically. A reference formant was presented, on two or the three sounds heard, on each trial. The remaining sound was heard, at a higher formant frequency. Listeners whose degree of hearing loss, ranged from severe to profound, had to indicate which of the three sounds were different from the other two. The reference formant locations were 225, 300, 430, 630 or 870 Hz. The investigators found large learning effects, and a weak positive correlation between hearing loss for pure tones and formant frequency discrimination, which averaged about 3% at 225 Hz and 15% at 870 Hz. Normal listeners discrimination being about .5%

Much of the current research implies that hearing impaired children recognize small differences in frequency, as well as do subjects with normal. Sensitivity or even hearing impaired adults (Gengel, 1969). Gengel (1969) states that, the DL of hearing impaired children can be as great as twenty times or more those of other subjects. He explains that such reduced performance, might primarily result from the lack of auditory experience, that accompanies auditory sensitivity, hence practice should reduce the DL size over time. This statement is in support of Lagenbeck’s view (1965).

Gengal (1969) studies the DL at 250, 500 Hz, or twenty three deaf and twenty one hard of hearing children in three practice sessions. Conditions included both fixed amplitude, where loudness could be confounded with pitch, and variable amplitude, where loudness and pitch varied independently.

Results indicated that the deaf group showed significant decreases in sizes of DL over three test sessions. The hard of hearing should significant decreases in the size of the DL over three test sessions for only one condition and the normal hearing children should a symptotic performance on the first test session. He concluded that there was a moderate correlation between hearing level and the size of DL at 500 Hz, and that small DL’s were found after limited practice for low frequencies, which should be encouraging for teachers of the deaf, especially for auditory training and in the teaching of intonation.

Madsen et al (1969) conducted an experiment on modulated frequency discrimination, in relation to age and musical training. Each subject had 15 tone stimulus presentations of thirty seconds duration each. The intensity level for all presentations of five ascending, five descending and five unchanged. The last five presentations were used to check reliability of the responses. To help control, for tonal memory, subjects heard 10 seconds of unfamiliar music between each presentation of stimuli. The subjects were only to indicate whether the tone was higher, lower or same. Results indicated that scores increases with age and with musical training. It was also noted, that as the age level of the group increased, more subjects tended to choose response for pitch as “down” and “same” also older subjects should improved discrimination. They report that the group of musicians appeared to have a propensity to choose “down” as their response.

The results in the second aspect of their experiment, indicated that subjects performed worse, when they took a longer time to discriminate. Hadsen et al (1969) Stat that the best time for correct discrimination was within the first five to ten seconds, after presentation of the modulation frequency. These investigators state that there was also a strong indication, that sex may be an important variable with males evidencing better discrimination than females.

Novak et al (1972) investigated frequency discrimination and ear for music using an audiometer. According to the possibilities of this instrument on 250, 500, 1000, 2000, 4000 Hz were measured with 0.2, 0.4, 0.6, 0.8, 1, 2, 3, 4, 6, 8 percent decrease or increase. The test was done at 30 and 60 dB thresholds, and their results indicated that percentage values of the frequency change sensation and that percentile change of the frequency number enabled subjects to distinguish semitone and whole notes.

In the field of Speech Pathology, pitch discrimination tasks, have been conducted mostly, on cases of misarticulation, and voice disorders, though the body of evidence, in this area, still remains, limited.

Farguhar (1961), Sommers (1962) have investigated, auditory discrimination ability in cases misarticulation. Farguhar's (1961) investigation indicated that children with mild articulatory defects had better auditory discrimination than children with severe misarticulations. Sommers et al (1961) reported that children with articulatory defects poorer in the ability to discriminate pitch changes than "children with adequate articulation".

Kuper (1972) states that speech training through musical ear training could be given for children with 'pitch deficiency', who had articulatory defects.

A sense of pitch, as the ability to perceive gross changes in pitch, and to discriminate whether a series of tones are ascending or descending in frequency is important as an adjunct to aural discrimination of musical tones and also speech sounds, (Sradley 1959, Sommers et al 1961). Ludin (1963) concludes that:

" . . . . pitch discrimination is behaviour which is not merely a function of a sense organ as was previously presumed, but behaviour or a discriminative sort developed through interaction with stimulus objects. This behaviour is subject to change and improvement through casual learning or by means of a continued situation where a prepared series of training procedures is prescribed"

Kuper (1972)in his review of earlier studies concludes that, persons with articulation defects often show poor pitch discrimination and short memory span for speech sounds (Stinchfield 1928, Clark, 1959, Shermen and Geith, 1967, Smith, 1967). He further states that Stinchfield in 1928, noted that children referred for speech correction, who also were poor in pitch discrimination, had greater difficulty in speech training than those "with a good musical ear" and "superior discrimination". Thus, a link seems to be established between musical ability and speech correctability (Kuper, 1972). Assuming that good pitch perception contributes to good articulation, Kuper (1972) questions whether in a speech defective child, trained improvement in pitch perception contributes to better articulations and concludes by stating that lost authorities agree that pitch discrimination, can be improved though there is a psychological limit (Smith 1914, Mainwarning 1931, Russell and Tate 1969, Wyatt, 1945). Auditory discrimination training have been, suggested by most of these authors, in the training procedures, for cases of misarticulations.

The common types of voice defects are hoarseness, huskiness, stridency, inappropriate pitch placement, hypernasality, denasality and a combination of these problems (Davis and Boone, 1967). According to these authors, clinical observations of these patients, with hyperfunctional voice disorders, suggest that many of these patients may experiences difficulty in signing a tune, matching a pitch, or discriminating between pitch. They suggest that patients with hyperfunctional voice disorders, therefore, ie., they may have impaired pitch discrimination and tonal memory which have impeded acoustic self monitoring process, necessary for normal vocal efficiency.

Anderson (1961) cites, "imitation of others, a poor sense of pitch, various adverse personality characteristics, emotional disturbances, strain and nervous tension" as among the causes of faulty pitch level.

A poor sense of pitch discrimination, has been stated as one of the possible causes of vocal monotony. Anderson (1961) defines monotony as an absence of change in pitch, loudness, tempo etc. It is established that before an individual "can introduce meaningful changes of loudness, tempo, pitch, or quality into his voice, he must first be able to hear those differences of atleast be aware of them" (Anderson 1961).

West, Ansberry and Carr (1957) state, that a person who cannot distinguish one pitch from another is said to be suffering from “tone deafness”. Tone deafness according to these authors, is a rare condition, and most individuals are able to discriminate between tones provided, they differ sufficiently in pitch, loudness duration or quality. The degree of actual difference required, however, has been found vary widely among individuals; some being able to recognize very small differences, while others are insensible to anything but wide variations. It is further stated that in addition to being able to discriminate differences between tones, the individual should have definite neuro-musclur co-ordination and control to enable him to reproduce those heard differences in his own voice. “Tone production is dependent on sensory perception and also involves motor process, involving doing, as well as hearing” (Anderson, 1961).

Anderson (1961) further states that “according to some authorities, a causal relationship between pitch discrimination, or the lack of it, and absence of adequate variety in the voice, may be suspected when the limit of the persons discrimination is 9 c.p.s. or more”.

Fairbanks(1948) states that the most common specific causes of pitch defects are, faulty pitch discrimination, poor tonal memory, poor motor control, and faulty learning.

Further, Judson and Weaver (1965) explain that pitch discrepancies, in the voice, when striking may be due to defects in the control of the laryngeal musculature. The defect, could be primary or secondary. They explain, that to produce a tone, corresponding to another tone, the ear mechanism (primary) is first called into activity, then the laryngeal muscles (secondary) are adjusted for position. The ear then, compares the two tones and if necessary, further laryngeal adjustments are made. The maintenance of the tone depends on the integrity of “the ear larynx-circuit” and particularly on the maintenance of the correct tensions of the laryngeal muscles. Hence, the inability on the ‘ears’ part to detect gross difference in tones will result in large unconscious variations in voice. Each individual has certain auditory habits, and these auditory habits are bound up with his speech habits. The ear does not automatically and without training receive speech sounds as such, instead, the speech sounds that will be perceived by the ear will depend on the sensitivities, to those differences, which distinguish speech sounds and on the experience of the listeners to familiar sounds. “Fine discrimination in the perception of speech sounds increase when the listeners produces sounds with his own voice and speech equipment” (Judson and Weaver, 1965).

West, Ansberry and Carr (1957) state:

> “In the absence of all other causes tending towards monotony of voice, a tone deafness with a limit of 15 cps or more may be regarded positively as the cause but the lack of pitch sensitivity to pitch differences is only one of the several possible factors which may operate to cause monotony of speech”

Variations in pitch occurs during/just after puberty due to growth of the laryngeal structures. The individual usually finds it difficult, to control his voice (pitch) because of the abrupt changes that take place in his larynx. During this period some individuals land up with a pitch that is not his optimum. This conditions which is termed puberphonia may also be related to poor pitch discrimination.

Shanta (1973) in a study of voice disorders has concluded that habitual frequency in most of the cases with voice disorders deviates from optimum frequency.

It is hypothesized that once voice disorders are established and monitoring and comparison fails, the auditory efficiency of these patients becomes an important area to be tested.

The use of discrimination tasks with dysphonics have been emphasized. Judson and Weaver (1965) used tuning forks to determine pitch discrimination ability in cases of voice disorders. Van Riper (1962) states that discrimination of pitch could be made using a simple procedure by whistling pairs of notes, at high, mid, and low and asking the subject of the first is higher or lower, than the second, “without having subjects see you”.

Anderson (1961) states, that the most convenient test for measure of sensory abilities related to speech are Seashore

Tests of musical ability. The tests include measures of pitch, and loudness, on the subtests. Each of the tests on pitch and loudness consists of fifty pairs of musical tones. In the test for pitch the fifty pairs of musical tones. In the test for pitch the fifty pairs are identical in loudness and very only in pitch. Subjects are directed to listen, to each pair of tones, and to judge whether, the second tone of each pair is higher or lower than the first. In the other subtest, the loudness is varied, as pitch is kept constant.

Preliminary studies on voice tracking behaviour were done by Elliot and Niemoeller (1968). Twenty one monaurally* hearing adults attempted to match their vocal fundamental to the frequency of tonal signals, presented either before or during vocalization, under a variety of conditions. Their subjects were not informed of the results of the test, and vocalizations were sustained for two seconds. It was found that subjects were within 1% of the target frequency on approximately half the trails, although they showed a tendency to be "on target" for as many as, 80% of the trails. Elliot and Niemoeller (1968) concluded that none of the measures of vocal pitch matching was related to the more classical auditory pitch matching.

In 1926, Travis and Davis used the Seashore Measure for pitch intensity and Tonal Memory to determine, the part played by these

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* Monaurally hearing adults – it was not explained by the experimenters if unilateral S.N. loss cases were taken (Parenthesis by present investigator)

abilities in certain speech defects. They found that the superior speakers differed significantly from defective speakers in the scores in all the 3 tests. Among the defective groups, the investigators found that the scores for the functional group were poorer, as compared to the organic speech defective group, contrary to their expectations. The speech defective group as a whole showed greater variability. In this study, all types of speech problems were grouped together and no attempt was made to investigate voice defectives separately.

Gilkinson (1943) studied the relationship of speech skills and the scores on the seashore Tests, with regard to normal speakers. He concluded that there was a relationship between speech skills and Seashore scores.

In a study by Horowitz (1949), attempts were made to investigate the correlation, of the ability as shown by the Seashore measures for pitch, loudness and rhythm with the effectiveness of speaking, as rated by judges. She found a slight relationship between speech skills and scores for rhythm and pitch discrimination, but found no relationship with regards to loudness discrimination, in normals.

According to a study by Eisenson, Kastein and Scheiderman (1958), voice defectives appeared to be inferior in pitch discrimination as compared to normal population. They investigated two aspects i.e., loudness and pitch discrimination abilities using Seashore Test in their group of voice defectives, comprising of a functional and organic group. They concluded that the voice defectives were not significantly poorer than the other group in loudness discrimination, there were no significant differences for either pitch or loudness discrimination between functional and organic groups. Davis and Boone (1967) studies pitch discrimination ability in a group of hyperfunctional voice disorders ("hyperfunctional in the sense, those voice problems related to excessive and abusive contraction of the muscles involved in phonation with or without subsequent development of laryngeal pathology" (Froschels 1943, Broadnitz 1961). Results of their study showed that this group did not vary significantly from the matched control subjects, in pitch discrimination and tonal memory as measured by the two subsets of seashore. They state, "that which was observed from the pathological listening behaviour in some voice patients, appeared in the same degree and frequency in matched controls".

Their study, was not intended to draw a cause and effect relationship between poor auditory listening abilities and the development of dysphonia, although their data suggest, for the voice clinicians certain important conclusions:-

1. That voice patients are probably similar to the normal population in their ability to discriminate pitch and remember tonal sequences

2. The individual patient, who is poor in pitch discrimination, and remembering tonal sequences, when compared to normals, will probably to unable to discriminate auditorily between what is a 'bad' voice and 'good' voice. For these patients the clinician may need to avoid using the patients "best" voice or another voice, as a therapy model.
3. That these measures and scores may given the clinician clues about the patients competence in musical listening relative to the normal population, hence subsequent vocal rehabilitation should be planned consistently with the patients listening abilities

Their study, however, did not substantiate the results of earlier studies by Eisenson, Kastein and Schneiderman (1958). The authors conclude that the discrepancy in the results, may be due to difference in control and experimental groups, and differences in scoring methods. Purther Davis and Boone (1967) observed in their study that for patients who received pre and post therapy Seashore measures, there was little or no improvement.

Most of the therapies of voice disorders are based on the belief, that each person has an optimum pitch at which the voice will be of good quality and will have the maximum intensity with least expense of energy. And they concern themselves mainly with altering the habitual pitch level of making the case use his optimum pitch (West et al 1957, Thurman 1958, Van Riper, Irwin 1958, Murphy 1964, Greene 1964).

Many clinicians stress on pitch discrimination and ear training in the treatment of voice patients. Van Riper (1963) while discussing therapy with voice patients, states that one of the way of using progressive approximation in voice therapy, is the use of a binaural auditory trainer, feeding cases voice into one ear and therapists model voice into the other ear, so that the patients has a simultaneous comparison to make. From unision slight changes towards the desired pitch are made, such that the patient unconsciously switches over to the new voice as he perceives it. “The basic development of the input modality in voice therapy, or appropriate phonation, is the appropriate auditory, system, especially patients self hearing” (Boone, 1967). Boone (1967) further states that many people rarely realize, how their voiced sound, until they hear their recorded sample, hence most clinicians fact a problem during therapy, with individuals who have lack of voice feedback. Some dysphonics, he continuous like some individuals in the normal population demonstrate poor pitch discrimination and tonal memory and these patients face more difficulty in voice therapy, in discriminating between pitches and remembering their own model voices. These patients according to Boone, can be given ear training to differentiate between the ‘good’ and the ‘bad’ voices, and voice training should include instructions in pitch discrimination. He concludes that the clinician should however, assess the patients ability in this area first, and only if deficient, in this aspect, will be patient benefit from such training.

West, Ansberry and Carr (1957) while discussing some of the problems faced, in changing the pitch, of an individual attribute a “poor Ear for Pitch”. And they consider this as one of the reasons, for failure in therapy. West et al suggest that pitch changes can be made visible by means of a tonoscope, so that by watching, he can control, that which he cannot control by hearing.

Anderson (1961) states that after the establishment of a desirable pitch level, it is important to make it habitual. He states that the carry over of the “newly found voice”, should be integrated in the total pattern of speaking, for it to become natural. The first carry over is often not easy to accomplish and for a time, “you may need to apply your mind consciously to the task of incorporating, the newly learned techniques into your ordinary speaking” (Anderson 1961). One should develop “the feel for the pitch”, as Anderson puts it.

Van Riper (1963) mentions that in most voice training programs, the basis is that of matching the voice with a model and hence the practice in auditory feedback is unduly important.

Hurphy, discussing the various methods of therapy for functional voice disorders indicates that auditory training including self listening, matching and comparing voices in quality loudness and pitch and imitation, are useful and should be used very frequently with all cases of functional voice disorders.

Shearer (1959), discussing the role of cybernetics in the treatment of voice disorders states that “we see that the established baseline is in terms of pitch loudness, and quality of the patients present voice . . . . . . unfortunately, the old voice too often persists as the reference line, and the patient returns to old habits outside the clinic”. Therefore it seems desirable to eliminate the old baseline of the habitual voice thus, inducing seeking behaviour, before presenting the new voice. The seeking behaviour is reinforced by repeatedly recording the patients voice at great many different pitches, asking him to indicate those that are most pleasing, and hence the patient soon because proficient in varying his voice and in modifying it is the direction of the required optimum pitch (Shearer 1959).

Jackoby and Bronstein (1967) suggest that one of the basic procedures in all voice training involves improvement in auditory discrimination. According to them “our hearing insists that the response first into a remembered pattern, “and the ear should ultimately be put in charge of this pattern. The techniques they propose for vocal change are based on the assumption that “you have a normal hearing, and that you have a third ear or listener, who will help you in the initial stages, but this function will be later taken over by your ears”.

Van Riper and Irwin (1968) in explaining MIDVAS as applied in voice therapy state that only after making discriminations and variations should the patient be instructed to produce the model pitch, by approximation, which should be finally stabilized.

Training procedures in frequency discrimination, have been incorporated in almost any kind of voice therapy; either with the help of visual clues or purely through the auditory modality.

The stroboscopic unit can be used in voice therapy where the patient gets the visual clues to the frequency of his voice. He can vary to the desired level, using these clues.

FLORIDA or the frequency lowering or raising intensity determining apparatus is used for voice therapy. The subject is told to phonate, after the instrument is set, at the optimum frequency of the patient, which is determined first. When the subject approximates the required level a light glows, which acts as a visual reinforce. If the vocal production deviates away from the one already set, another light glows to indicate the deviation. Hence the subject can guide himself, the desired level. Though the visual modality is primarily used, the subject should be made aware of the auditory self monitoring process, by which he has to adjust his vocal production.

Shanta (1973), used a technique of voice therapy, the isochronal tone stimulation. The optimum frequency is determined first then the habitual frequency. The habitual frequency is fed to the vibrator of the artificial larynx, from the oscillator.

This artificial larynx is placed at the laryngeal level. When the frequency from the oscillator approximates the habitual frequency, phonated by the individual, a sensation of beats is felt. The frequency of the vibrator is gradually altered towards the optimum frequency, in small steps and the individual is required to approximate the frequencies at all these steps to reach the desired frequency. This is done by progressive approximation. Then this frequency is generalized to other situations where the individual may control this by auditory feed-back. Most of the techniques of vocal rehabilitation utilize the ear's monitoring capacities, to a great extent. Though in some techniques, other clues are given initially the carry over of the newly acquired voice (which is an important step in voice therapy) ultimately relies on the five discriminative powers of the ear. Thus the review of literature shows that there could be a relationship between frequency discrimination ability of the ear and production of voice. Poor frequency discrimination has been correlated with voice disorders. Eisension et al (1958) believes:

> "that poor pitch discrimination may be a causal factor in the development of voice disorders association with poor pitch placement or in the difficulty, the voice defective may have in modifying poor pitch placement even when this is not the original basis for the voice disorder, as in organic voice problems. . . . ."

Some investigators, Boone (1961) Van Riper and Irwin (1958) Eisenson et al (1958) even utilize frequency discrimination capacities of dysphonics as a prognostic indicator, as cited earlier. The present study aims to investigate the relationship between dysphonia and frequency discrimination ability in an Indian population. It is intended to see if people trained in music would have better discrimination.

CHAPTER III

METHODOLOGY

A pilot experiment was done to develop a suitable method to measure frequency discrimination.

Experiment 1 – Test Room

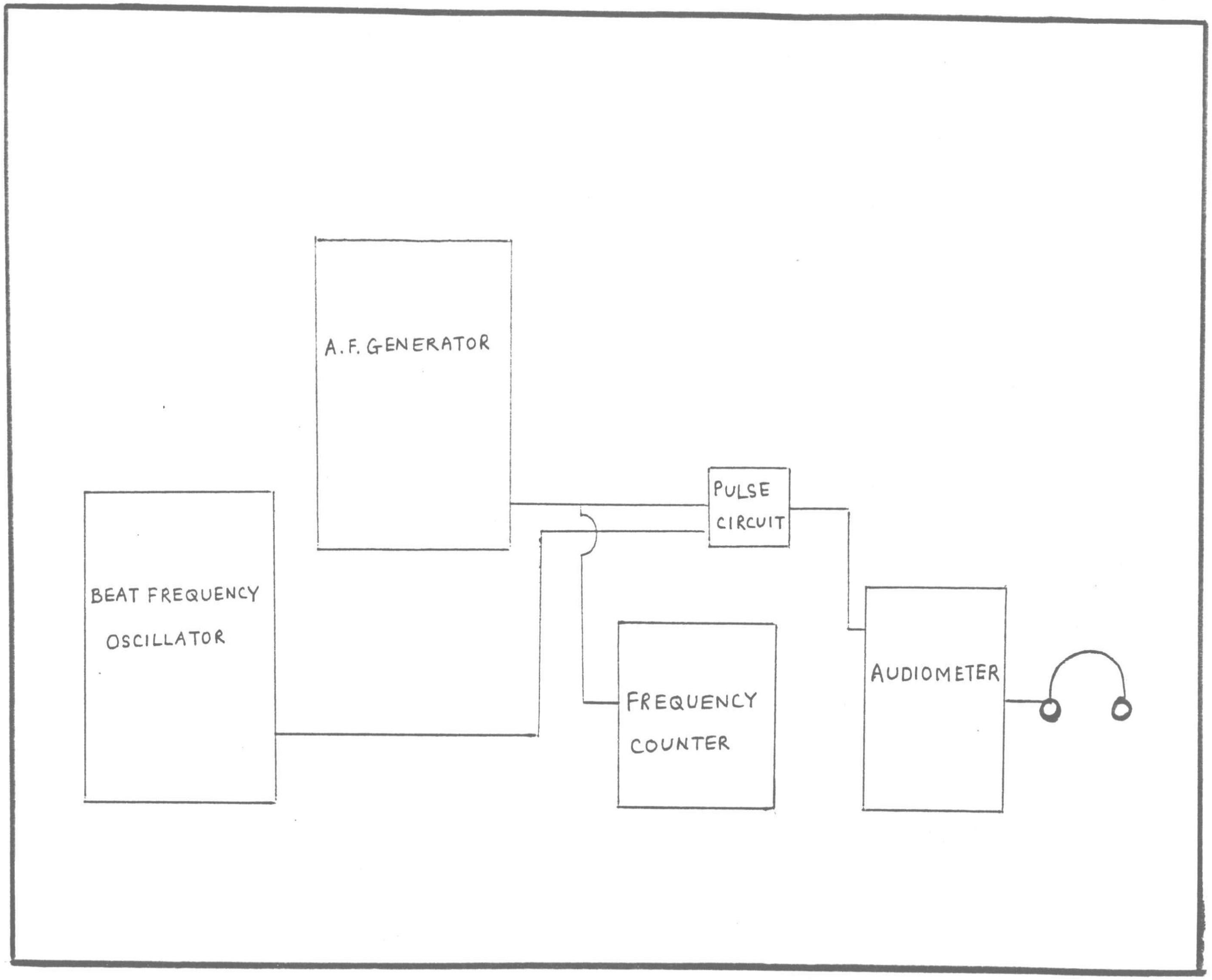
The experiment was done in one of the rooms in the department of Electronics. The subjects were seated in an acoustically treated booth. The noise level of the booth is indicated in the following table: -

NET WORK

	A	B	C
1	30 dB	38 dB	42 dB
2	32 dB	38 dB	44 dB
3	33 dB	35 dB	40 dB

Subjects

Five normal hearing subjects who had no voice defect, were selected randomly.


A.F. GENERATOR
PULSE CIRCUIT
BEAT FREQUENCY OSCILLATOR
FREQUENCY COUNTER
AUDIOMETER

Instruments used

1. A.F. Generator (Philips GM 2308/90)
2. Frequency Counter (Type 702)
3. Beat Frequency Oscillator (B & K Type 1022)
4. Beltone 12 D Audiometer
5. Pulse Circuit (Detains of instruments is given in Appendix-1)

Set Up

The Beat Frequency Oscillator and A.F. Generator were calibrated to power frequency of 50 Hz, using an Oscilloscope. The two generators were also calibrated using the Audio-Frequency Analyzer. The frequency output of the B.F.O. and A.F. Generator were checked, from time to time using the frequency Counter. Block diagram 1, shows the arrangement of the equipment.

The output signals from both generators relayed alternately, for fixed durations (2.8 Secs). This was made possible using a pulse circuit developed for this purpose.

The B.F.O. and the A.F. Generator, were each separately adjusted, such that they gave the same intensity output. This was checked using the V.U. meter of the audiometer. Finally the intensities of the two tones were controlled by the attenuator of the audiometer.

Prior to testing, the hearing thresholds, of the five subjects were taken using the audiometer for three frequencies, 125, 250,500 Hz. Hearing thresholds of same subjects, were measured using the B.F.O. for the five test frequencies, 100, 200, 300, 400, 500 Hz. Since the threshold, did not vary much (5 dB variations) using the two methods, the audiometer, was used to measure the thresholds. The frequencies selected for the study were 100, 200, 300, 400 and 500 Hz. These frequencies were selected as this covered the modal frequency range of vocal output, of adult males and females. The right ear was arbitrarily chosen as the test ear.

The instruments, were arranged, as shown in the block diagram.

Procedure

1. The subjects were then given written instructions as follows:-

“You will now hear a tone, in your right ear. when the tone stops, it will be immediately followed by another tone and so on. You have to listen carefully to the tones, and when you think that there was a difference between the preceding and the following tone, tap on the glass pane”

e.g. of test tone – 100Hz 102Hz 100Hz 104 Hz

2. Both the tones were given at a constant intensity of 40 dB sensation level.

3. The tones alternated from the referent to the comparison. The referent from A.P.G. remained a constant frequency while the comparison tone, from B.F.O. was increased in 2 Hz steps, beginning with no difference. The comparison tone was changed when the referent tone was on.
4. When the subject indicated that there was a difference, an additional comparison tone was presented to ensure that the subject was sure of his response. The levels of discrimination in terms of Hertz were recorded.

Limitations

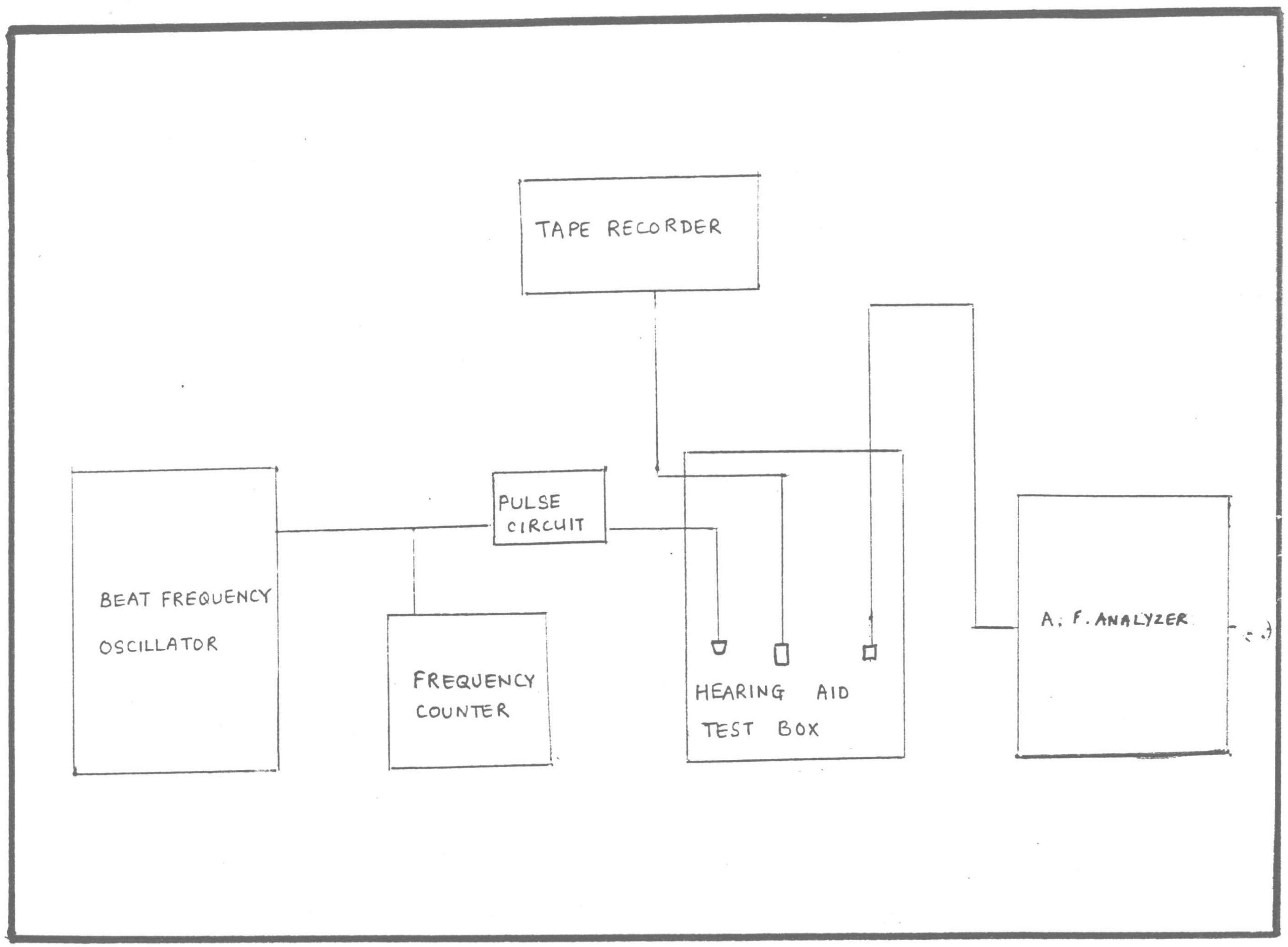
It was found that this method, presented several problems:

1. Manipulation of the frequency dial in terms of 2 Hz steps, was done manually and this presented errors, i.e., the output did not always match with the set frequency when checked with frequency counter.
2. The change of comparison frequency had to be done, during a short period (2.8 secs). This was bound to present errors, even with practice.
3. Though the frequency counter, was used from time to time to note the (output signals) comparisons tone present to the subject, it was not possible to adjust each ongoing tone to the required level.

Because of these problems the method could not be relied upon, to measure frequency discrimination. Hence, a more suitable method, was tried to overcome these problems.

Experiment II

In the first part of the experiment, the test material was recorded.


TAPE RECORDER
BEAT FREQUENCY
OSCILLATOR
PULSE
CIRCUIT
FREQUENCY
COUNTER
HEARING AID
TEST BOX
A. F. ANALYZER

The material was recorded, in the same room, where the previous experiment was conducted.

Instruments used for recording and set up

1. Beat Frequency Oscillator (B & K Type 1022)
2. Audio Frequency Analyzer (B & K Type 2107)
3. Pulse Circuit
4. Frequency Counter (Type 702)
5. Tape Recorder with Microphone
6. Hearing Aid Test Box (B & K Type 4217)
7. Condenser Microphone (B & K Type 4224)
8. Hearing Aid Receiver (Earphones – Danaid S 8-21)

The Beat Frequency Oscillator was calibrated to the power frequency of 50 Hz, using an oscilloscope. Characteristics of the tape recorder, were checked. The frequency counter was checked, before starting the recording.

The instruments were set up as follows for recording (and as shown in the block diagram -2)

The output of the B.F.O. was fed to the pulse circuit, which was developed for the purpose, of maintaining a constant duration of 2.8 seconds. Signal from this was fed to the hearing Aid receiver, which was placed in hearing aid test box.

A part of the output signal was given to the frequency counter, to note the frequency of the signal. The condenser microphone of the A.F. analyzer along with the hearing aid receiver, was placed in the hearing aid test box. This served to note the intensity of the output signal.

The output signal from the receiver was tape recorded. The microphone of the tape recorded was also placed in the hearing aid test box.

With this set up, recordings were made, from 100-500 Hz pairs of pure tones were recorded beginning with no difference in frequency, and then increasing the frequency of the second tone of the pair, in two Hz steps, until a maximum difference of twenty hertz was reached.

Hence for each of the five frequencies, a total of twenty pairs of pure tones were recorded. Between each pair of pure tones there was a time lapse of 10 seconds approximately and a time lapse of one second between each pure tone of the pair. The counter of the tape recorder was used to maintain a constant interval between the tones while recording. Frequency of the recorded material was analyzed using the stroboscope unit and that of duration and intensity using A.F. analyzer and level recorder. These tapes were used as test material which was fed through the head set of the audiometer.

The set up was such that the experimenter could adjust the tape recorder and audiometer from outside the booth while the subject sat inside the booth with the head set on.

100 Hz _ 102 Hz 10 Secs 100 Hz _ 102 Hz
1 sec

Experiment – 2 was carried out as follows:

Subjects

To serve as a subject in any of these experiments each individual was required to have normal hearing.

a) To test the superiority of the ear for frequency discrimination:

In this experiment forty normals served as subjects thirteen meals & 27 females whose discrimination scores of both right and left ears we taken

b) To test the relationship between the sex and frequency discrimination:

The subjects of this experiment consisted of thirty males and thirty five females. The ages ranged from seventeen years to 30 years. Some of the subjects of experiment 2(a) were included in this group.

c) <u>To test the frequency discrimination in dysphonics</u>

This experiment consisted of thirty two dysphonics ranging from the ages fifteen years to thirty four years. Each individual had to undergo otolaryngological examination, and diagnosis of the voice problems was made by a speech pathologist. Twenty nine subjects presented no organic problem.

d) <u>To test the frequency discrimination in people trained in music</u>

Twenty seven females who had undergone atleast one 'year's formal training in music either vocal or instrumental served as subjects for this experiment. These subjects were also required to have normal hearing and normal voice. The age range of this group was from 16 to 30 years.

Table showing number of subjects in each experiment

Experiment – 2

	Males	Females
a.	13	27
b.	30	35
c.	22	10
d.	-	27

Procedure

The procedure followed for all the four experiments was the same:-

1. All subjects were tested for hearing, fro the three frequencies 125, 250, 500 Hz in the conventional audiometric manner. For the first group alone, both ears were tested, while for the other three groups, only the right ear was tested.
2. The subjects were given written instructions as follows:-

   "In the same ear you will now hear a tone, which when stops, will be followed by another tone. Compare with first tone with the second, and if you think, there is a difference between the two tones raise your finger.

   If you think that there is no difference, wait for a while, and you will again hear two tones. Compare these two tones, and raise your finger, if you find a difference between these two".

3. If any of the subjects had doubts, regarding the instruction, they could ask the experimenter.
4. The recorder material was fed through the head set at a sensation level of 40 dB, adjusted in the audiometer. Since the thresholds were taken only for 125, 250 and 500 Hz, the presentation level of the test material (100, 200, 300, 400, 500) were based on these three thresholds i.e., SL for 100 was based on threshold of 125, for 200 on 250, 300 on 350, 400 & 500 on 500 Hz.

5. The test began with 100 Hz tones. When the subject indicated that he/she could detect a difference between the two tones, as additional pair was presented (i.e., the next pair) to ensure that the subject was sure of his response. The test was then proceeded with 200 Hz and so on.
6. The V.U. meter of the tape recorder was used to note, each pair on going stimuli. Responses were recorded in terms of the number of Hertz required to discriminate the two tones, for each frequency. The counter of the tape recorder, was used to indicate the frequencies. Five normals, and five dysphonics selected randomly were retested for reliability. This was done after an interval of one month.

The data was analyzed statistically. Means and standard deviations for each group were computed. To find the significance of difference between groups, Mann-Whitney U test (non parametric) was used.

CHAPTER IV

RESULTS AND DISCUSSIONS

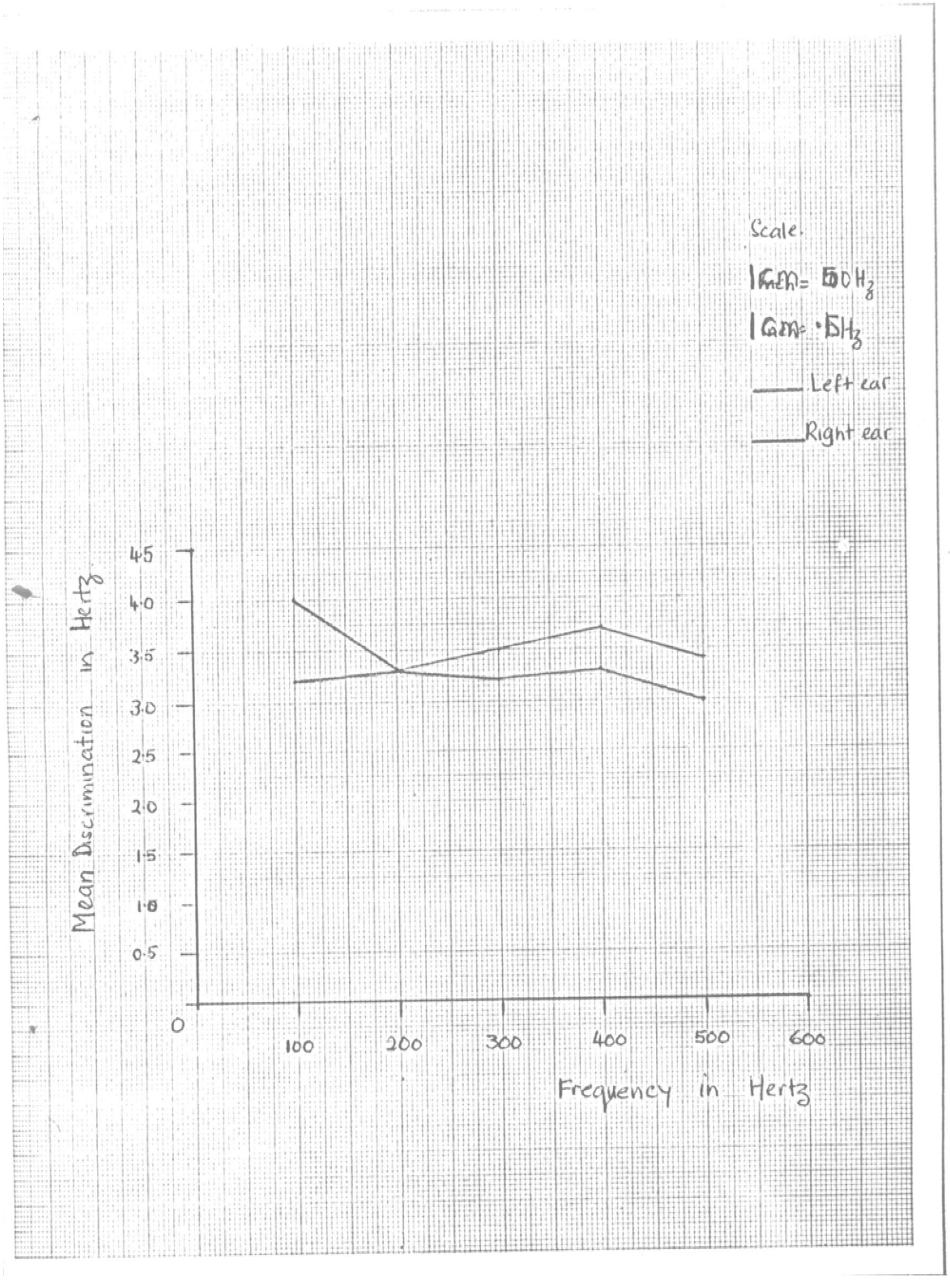
A pilot study i.e., experiment I, was done, which provided guidelines for the method of testing adopted in this study. Experiment II, a, b, c and d were then conducted and the results, have been statistically analyzed, Experiment II (a) using Mann-Whitney U test (one- tailed).

Frequency discrimination of right and left ears

The frequency discrimination scores or right and left ears ranged from 0 – 10 Hz.

Table I, showing the means and standard deviations of frequency discrimination of right & left ears

Freq in Hz	Rt/Lt Ears	Means	S.D.	
100	Rt	4.00	24.76	
	Lt	3.25	20.29	
200	Rt	3.35	20.91	
	Lt	3.30	20.61	
300	Rt	3.55	22.15	
	Lt	3.20	19.91	
400	Rt	3.75	23.42	
	Lt	3.30	20.61	
500	Rt	3.40	21.23	
	Lt	3.00	20.33	
Mean on whole Test Rt, Ear		3.26	S.D. on whole Test Lt, Ear	20.33
Mean on whole Test Lt, Ear		3.61	S.D. on whole Test Rt, Ear	19.95



Scale.
Left ear
Right ear
Mean Discrimination in Hertz
4.5
4.0
3.5
3.0
2.5
2.0
1.5
0.5
0
100
200
300
400
500
600
Frequency in Hertz

An examination of this table shows that there is no difference between the means of both ears, at all five frequencies and on the test as a whole. Similarly a comparison of standard deviations shows no difference between the two ears at all frequency levels, and thus the two ears seem to be equally variable.

A comparison of mean discrimination scores, for the test frequencies, for right and left ears is shown in graph I. The raw data of this experiment is given in appendix II. Further statistical examination was done using Mann – Whitney U test to find the significance of difference between the scores of the two ears. The test of significance was applied for all frequencies separately and for the test as a whole. Analysis was also done for the male and female groups separately.

Table II showing the Z values obtained for each frequency by the right and left ears

Freq. in Hz	Z values	Levels of Significance	
		.05	.01
100	2.31	R	A
200	1.40	A	A
300	0.06	A	A
400	0.84	A	A
500	0.96	A	A

On whole test	Z values	Levels of Significance	
		.05	.01
	.105	A	A

Applying the test of significance it was found that Ho was accepted at .01 level of significance for all frequencies. It was also found, that there was no statistically significant difference between the two ears, on the test as a whole.

Table III showing Z values for each frequency for males and females

Freq in Hz	Sex	Z values	Levels of significance	
			.05	.01
100	M	1.384	A	A
	F	1.494	A	A
200	M	0.692	A	A
	F	0.462	A	A
300	M	0.974	A	A
	F	0.103	A	A
400	M	1.00	A	A
	F	0.216	A	A
500	M	0.435	A	A
	F	1.117	A	A

		Z values	Levels of Significance	
On whole test	M	.230	A	A
On whole test	F	1.773	R	A

A study of this table shows that there is no difference in frequency determination between the ears, for either sex. It was found on statistical analysis that there was no significant difference between the two ears for either group. This was seen at all frequencies and, also on the test as a whole. The results of this experiment indicate that hypothesis (3) “that the right and left ears perform equally well in frequency discrimination task” is accepted. The hypothesis is accepted at all frequency levels, and also on the test as a whole.

Studies on dichotic listening have shown the left ear is superior in recognition of melodic line of sung speech (Bartholomeus, 1974), and also in the recognition of emotional tone of spoken sentence (Haggard and Parkinson, 1971). It was been hypothesized by studdert – Kennedy and Shankmeiler and Pisoni (1972) that purely auditory analysis of speech may be accomplished by the general auditory system, common to both hemispheres.

In the frequency range (100-500 Hz) that was used in the present experiment, the left and right ears did not show any significant difference statistically.

Experiment II (b)

Frequency discrimination ability between males and females

This experiment was done to find out the discrimination ability of both sexes. Frequency discrimination scores of this group ranged from 0 – 12 Hz.

Raw Data of this experiment is give in Appendix II

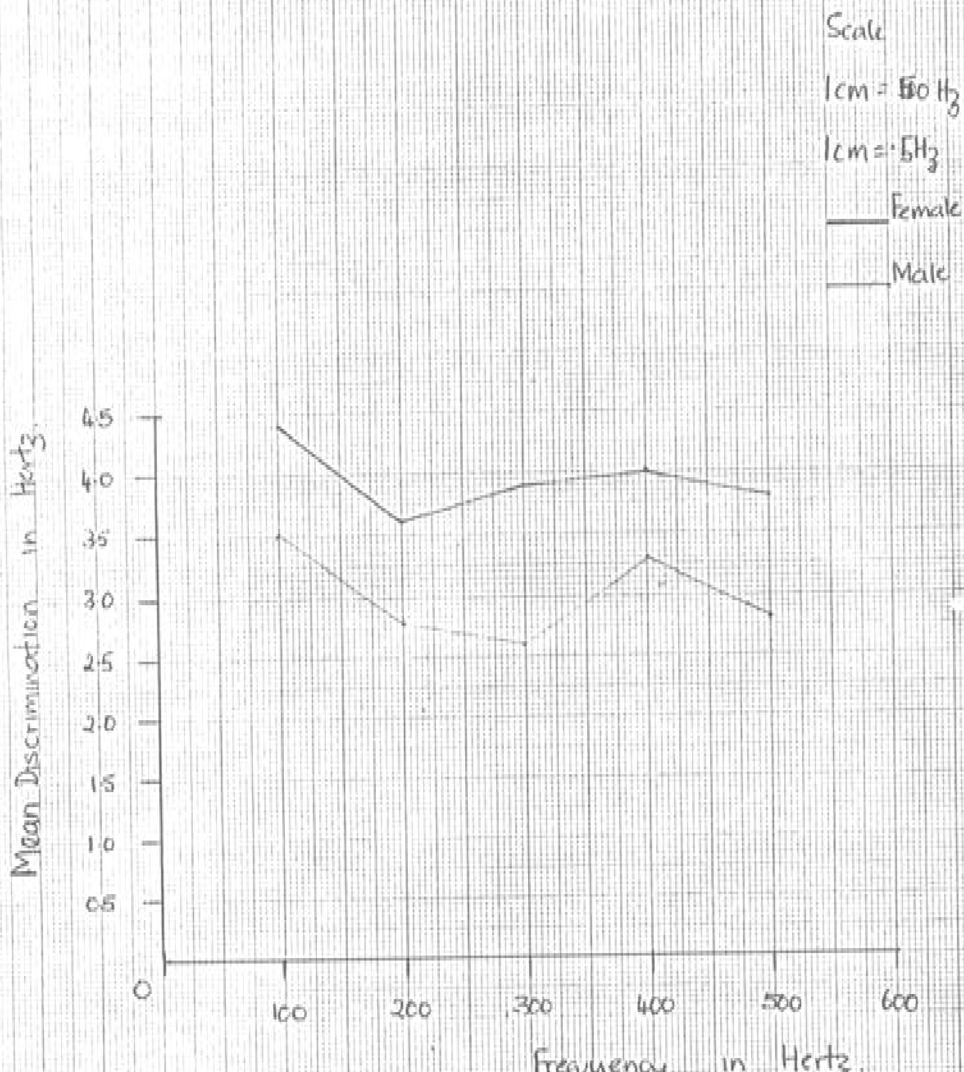

Scale
1cm = 50 Hz
1cm = ·5Hz
Female
Male
Mean Discrimination in Hertz
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
100
200
300
400
500
600
Frequency in Hertz.

Table IV showing means and S.D's of frequency discrimination ability of males and females

Freq in Hz	Sex	Means	S.D.	
100	M	3.5	19	
	F	4.4	25.99	
200	M	2.8	15.08	
	F	3.6	21.30	
300	M	2.6	14.00	
	F	3.9	22.68	
400	M	3.3	17.58	
	F	4.00	23.32	
	M	2.8	15.46	
	F	3.8	22.32	
Mean on whole Test (Males)		3.0	S.D. on whole Test (Males)	16.34
Mean on whole Test (Females)		3.9	S.D. on whole Test (Females)	23.18

A comparison of means between males and females at all five frequencies seem to indicate that there is a difference between the sexes with males performing better than females. The means of these groups are represented in graph II. Similarly a comparison of S.D's shows that females appear to be more variable than males. Also on the test as a whole, the mean value is lower than that of females, indicating males to be superior in this performance.

Further statistical treatment of this data for the significance of differences between the two groups was done.

Table V showing Z values of males and females in frequency discrimination

Freq. in Hz	Z values	Levels of Significance	
		.05	.01
100	1.82	A	R
200	1.44	A	A
300	2.27	A	A
400	1.38	A	A
500	1.27	A	A
On whole test	2.756	R	R

As can be seen from the table, hypothesis (2) is accepted at all frequencies at .05 level of significance. At .01 level of significance, the hypothesis is rejected at 100 Hz and 300 Hz and accepted at the remaining three frequencies.

The performance on the test as a whole, revealed that there is a statistically significant difference between the two groups: Hypothesis 2, that “there is no difference in frequency discrimination ability between the sexes” is therefore rejected; Males perfuming better in this task than females. Statistical analysis was also done to find out the significance of differences, between frequencies in male and female groups. Results revealed that there is no significant difference between frequencies either in the males or female group.

In this regard, Madsen et al (1969) state that “it should be mentioned that sex may be an important variable with males, evidencing better aural discrimination than females”. Results of the present experiment indicate that there was a difference between sexes, in frequency discrimination. In the normal group males being superior in this task while in the female group dysphonics performance better.

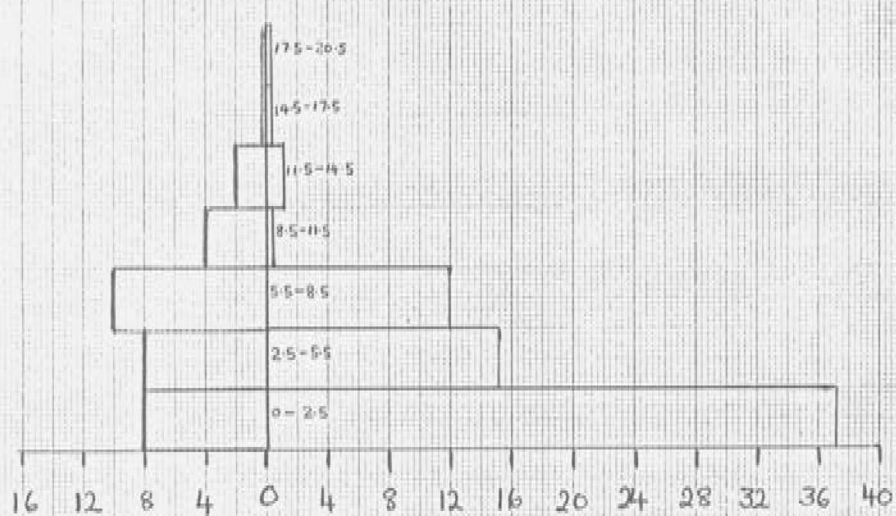
Madsen et al (1969) in their study have not cited any reference, on the difference between sexes in frequency discrimination. However, they caution that additional studies should control for sex differences.

Further studies on these lines covering a wider frequency range would provide information in this regard.

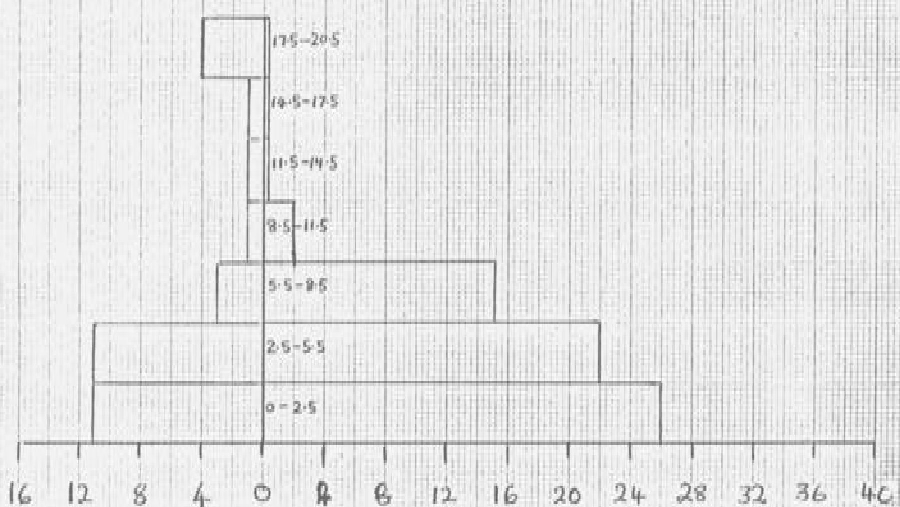
Experiment II (c)

Frequency discrimination between normals and dysphonics

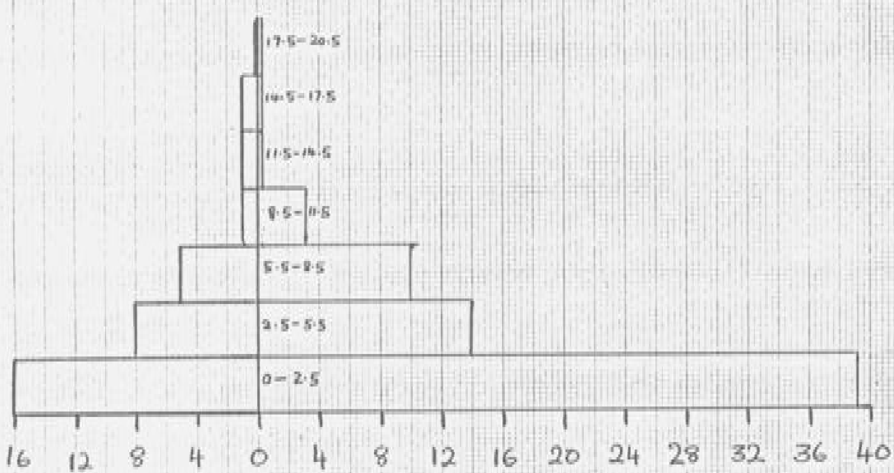
The raw data of this experiment is presented in Appendix II.



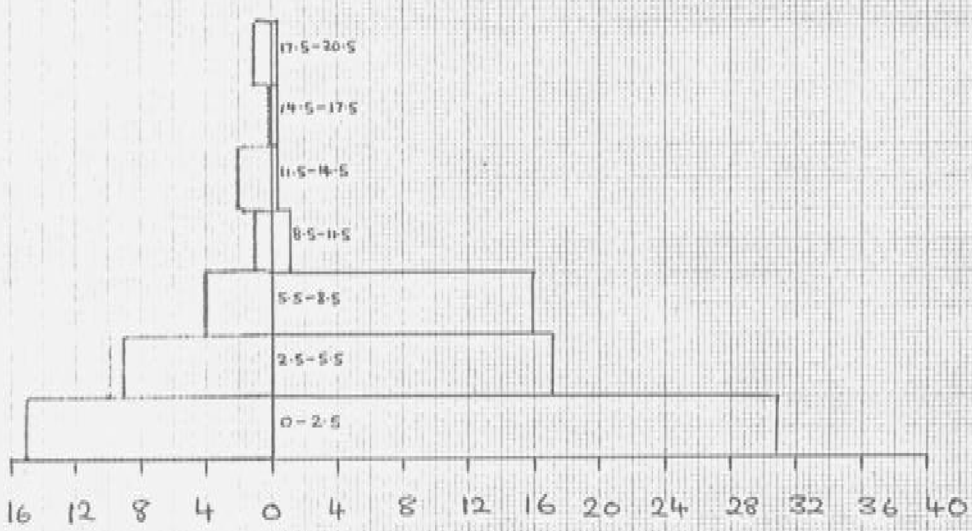
17.5 – 20.5
14.5 – 17.5
11.5 – 14.5
8.5 – 11.5
5.5 – 8.5
2.5 – 5.5
0 – 2.5
16 12 8 4 0 4 8 12 16 20 24 28 32 36 40



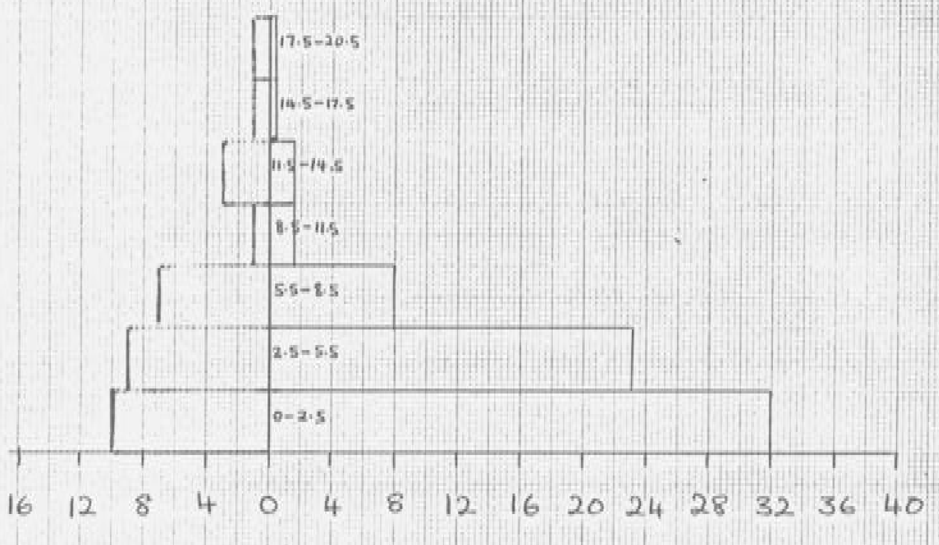
17·5–20·5
14·5–17·5
11·5–14·5
8·5–11·5
5·5–8·5
2·5–5·5
0–2·5
16 12 8 4 0 4 8 12 16 20 24 28 32 36 40



17·5 – 20·5
14·5 – 17·5
11·5 – 14·5
8·5 – 11·5
5·5 – 8·5
2·5 – 5·5
0 – 2·5
16 12 8 4 0 4 8 12 16 20 24 28 32 36 40



17·5–20·5
14·5–17·5
11·5–14·5
8·5–11·5
5·5–8·5
2·5–5·5
0–2·5
16 12 8 4 0 4 8 12 16 20 24 28 32 36 40



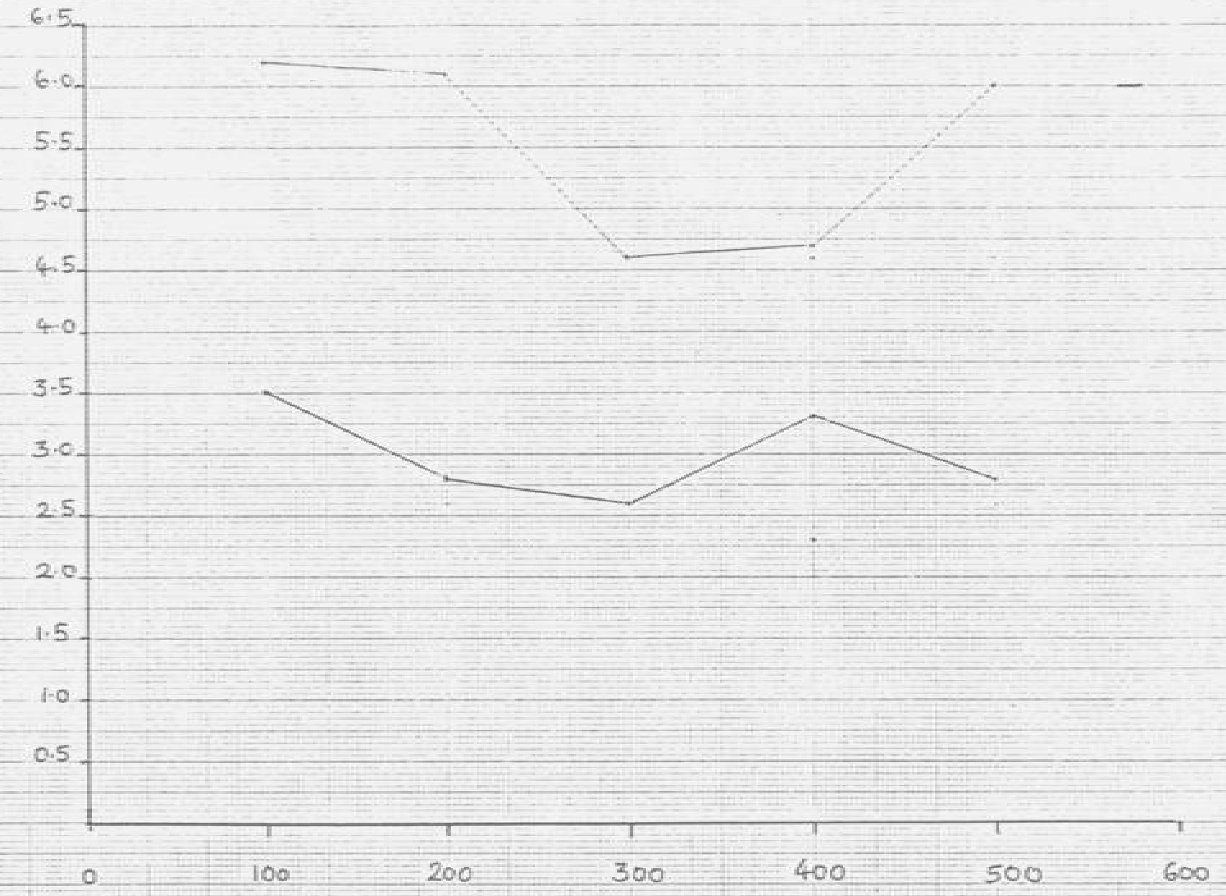
17·5–20·5
14·5–17·5
11·5–14·5
8·5–11·5
5·5–8·5
2·5–5·5
0–2·5
16 12 8 4 0 4 8 12 16 20 24 28 32 36 40

The frequency distribution scores fro each test frequency is shown in graphs III a,b,c,d,e. The frequency discrimination ranged from 0- 10 Hz in normal males, and 0-12 Hz in females. In male dysphonics the range was from 0 – 20 Hz, while in female dysphonics it was from 0 – 16 Hz.

<u>Table VI(a) showing the mean and S.D. of frequency discrimination of dysphonics and normals (Males)</u>

Freq in Hz	Normals(N)/ Dyspho(D)	Means	S.D.	
100	N	3.50	19	
	D	6.27	28.73	
200	N	2.80	15.08	
	D	6.18	28.32	
300	N	2.60	14.00	
	D	4.63	21.26	
400	N	3.30	17.58	
	D	4.72	21.64	
500	N	2.80	15.46	
	D	6.00	27.49	
Mean on whole Test (Normals)		3.0	S.D. on whole Test (Normals)	16.34
Mean on whole Test (dysphonics)		5.56	S.D. on whole Test (dysphonics)	25.71

The table on inspection shows that the mean scores for normals, at all frequency were lower than that of dysphonics.

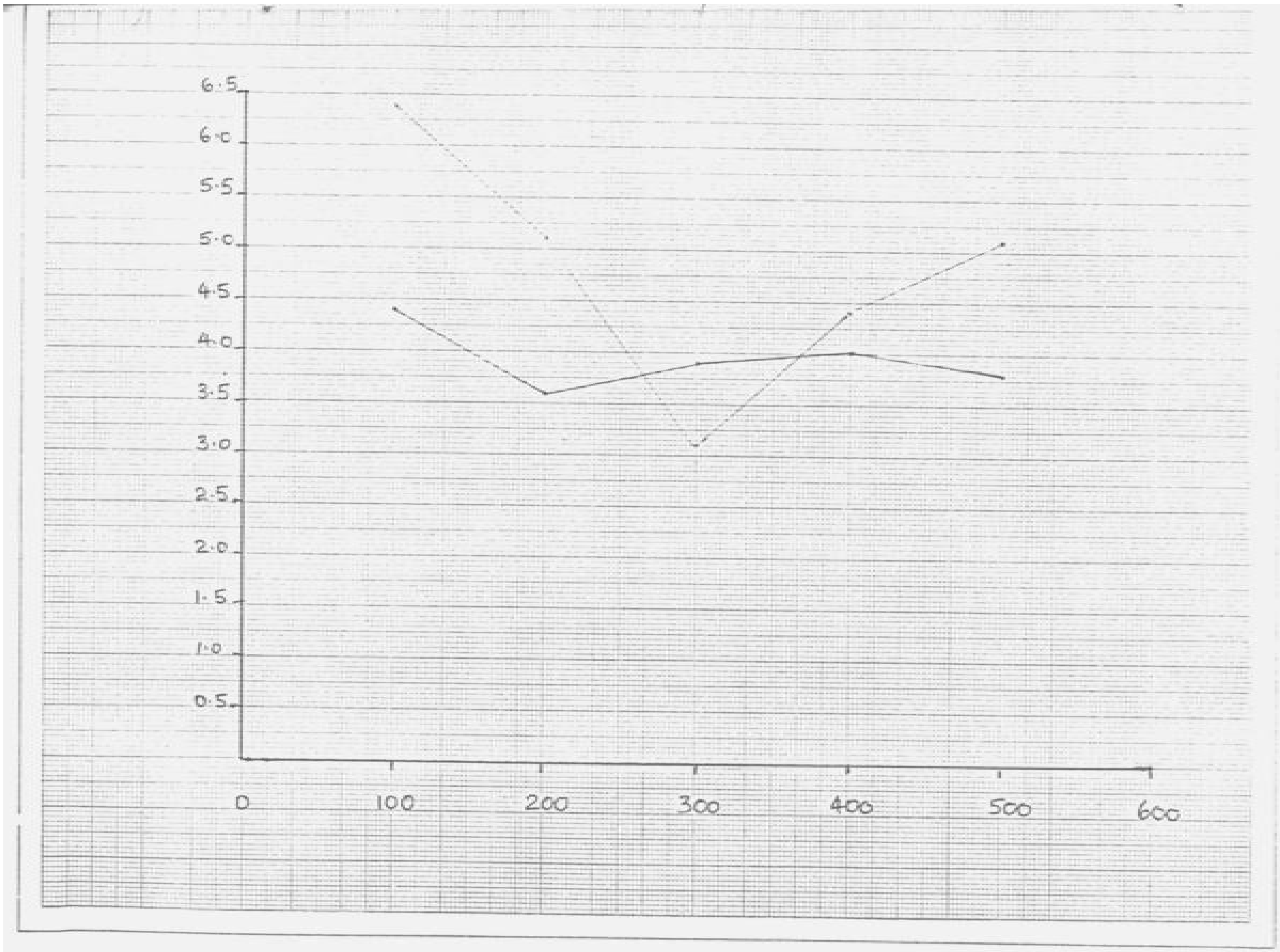

6·5
6·0
5·5
5·0
4·5
4·0
3·5
3·0
2·5
2·0
1·5
1·0
0·5
0
100
200
300
400
500
600

From this it may be inferred that the performance of dysphonic males in this task is poorer than that of normal males. This is shown in graph IV. Also the variability is greater in dysphonics.

Table VI (b) showing Z values of normal males and dysphonic meals

Freq. in Hz	Z values	Levels of Significance	
		.05	.01
100	1.694	A	R
200	1.867	A	R
300	2.423	R	R
400	0.404	A	A
500	3.647	R	R
On whole test	1.663	R	A

On applying the test of significance it was found that there is an acceptance of hypothesis (1) at there frequencies (100, 200, 400 Hz) at .05 level of significance and rejected at 300 Hz and 500 Hz. At 0.01 level of significance the hypothesis is rejected at all frequencies except at 400 Hz. However, on the test as a whole, it was found that there is no significant difference between normal males and dysphonic males. Hypothesis (1) is therefore accepted in this group.


6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
100
200
300
400
500
600

<u>Table VIII(a) showing the means and S.D. of frequency discrimination of normals and dysphonics (Females)</u>

Freq in Hz	Normals(N)/ Dysphonics(D)	Means	S.D.
100	N	4.4	19
	D	6.4	18.51
200	N	3.6	21.30
	D	4.6	13.80
300	N	3.9	22.68
	D	2.8	8.40
400	N	4.0	23.32
	D	4.0	12.00
500	N	3.8	22.32
	D	4.6	13.80
Mean on whole Test (Normals)	3.9	S.D. on whole Test (Normals)	23.18
Mean on whole Test (dysphonics)	4.4	S.D. on whole Test (dysphonics)	12.27

The table on examination shows that the mean values obtained by dysphonic females for three frequencies (100Hz, 200Hz and 500Hz) are higher than normal females. At 400 Hz no difference is seen in the mean values, while at 300 Hz the dysphonics appear to perform better. Graph V a,b,c,d,e shows this comparison. The mean value on the test as a whole indicates that normals performs better compared to dysphonics.

The variability in the female dysphonic group appear to be less compared to normal females.

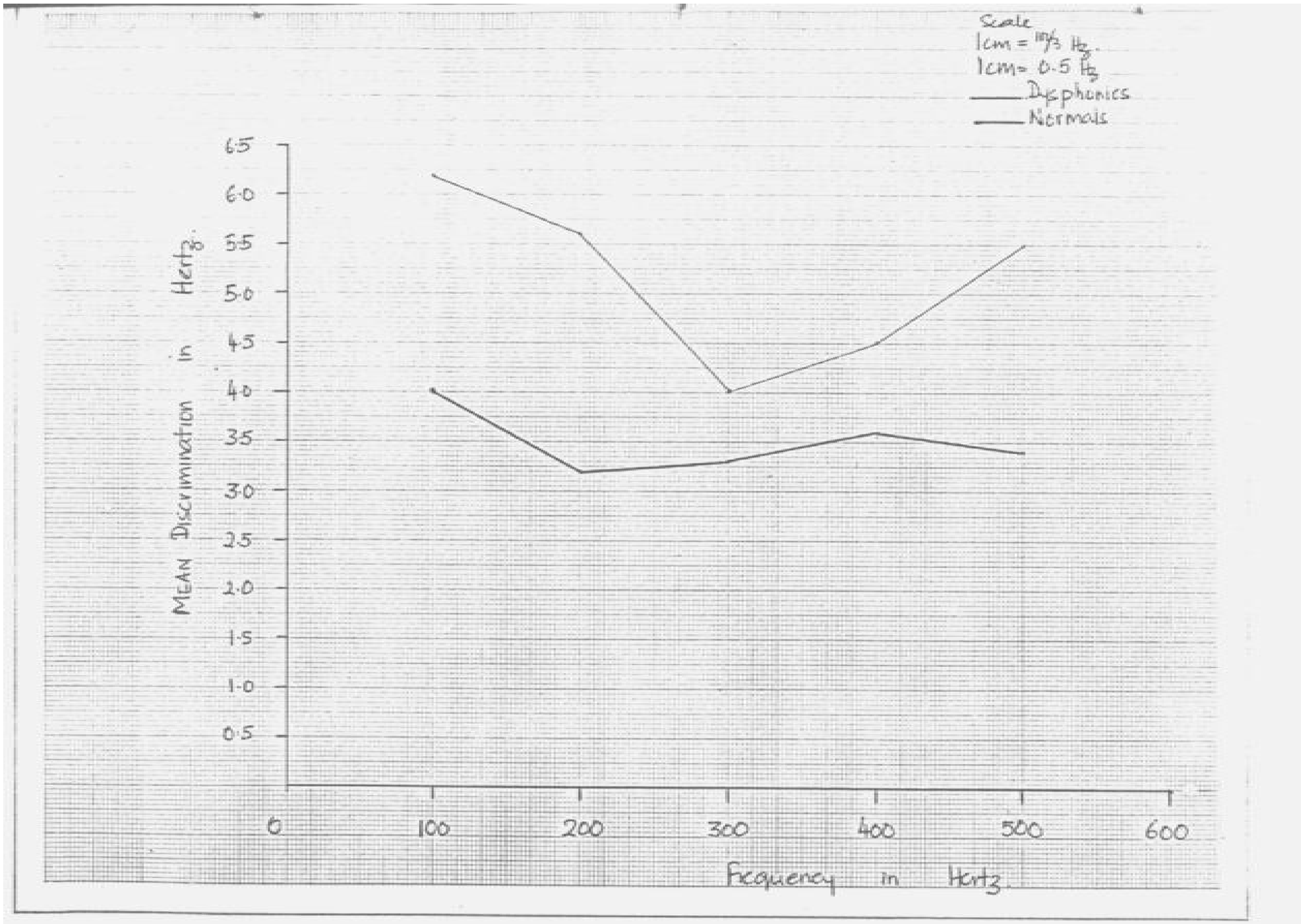

Scale
1cm = 100/3 Hz.
1cm = 0.5 Hz
Dysphonics
Normals
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
MEAN Discrimination in Hertz.
0
100
200
300
400
500
600
Frequency in Hertz.

Table VII (b) showing the Z values of normal females and dysphonic females

Freq. in Hz	Z values	Levels of Significance	
		.05	.01
100	4.888	R	R
200	1.118	A	A
300	1.195	A	A
400	0.153	A	A
500	0.321	A	A
On whole test	0.299	A	A

Total group on whole Test (F & M)	4.57	A	A

The table shows that hypothesis (1) is accepted at four frequencies (except at 100 Hz) at .01 and .05 levels is significance.

On further statistical analysis, no significant difference in performance was seen between normal females and dysphonic females, on the whole test. Hypothesis (1) is also rejected in this group.

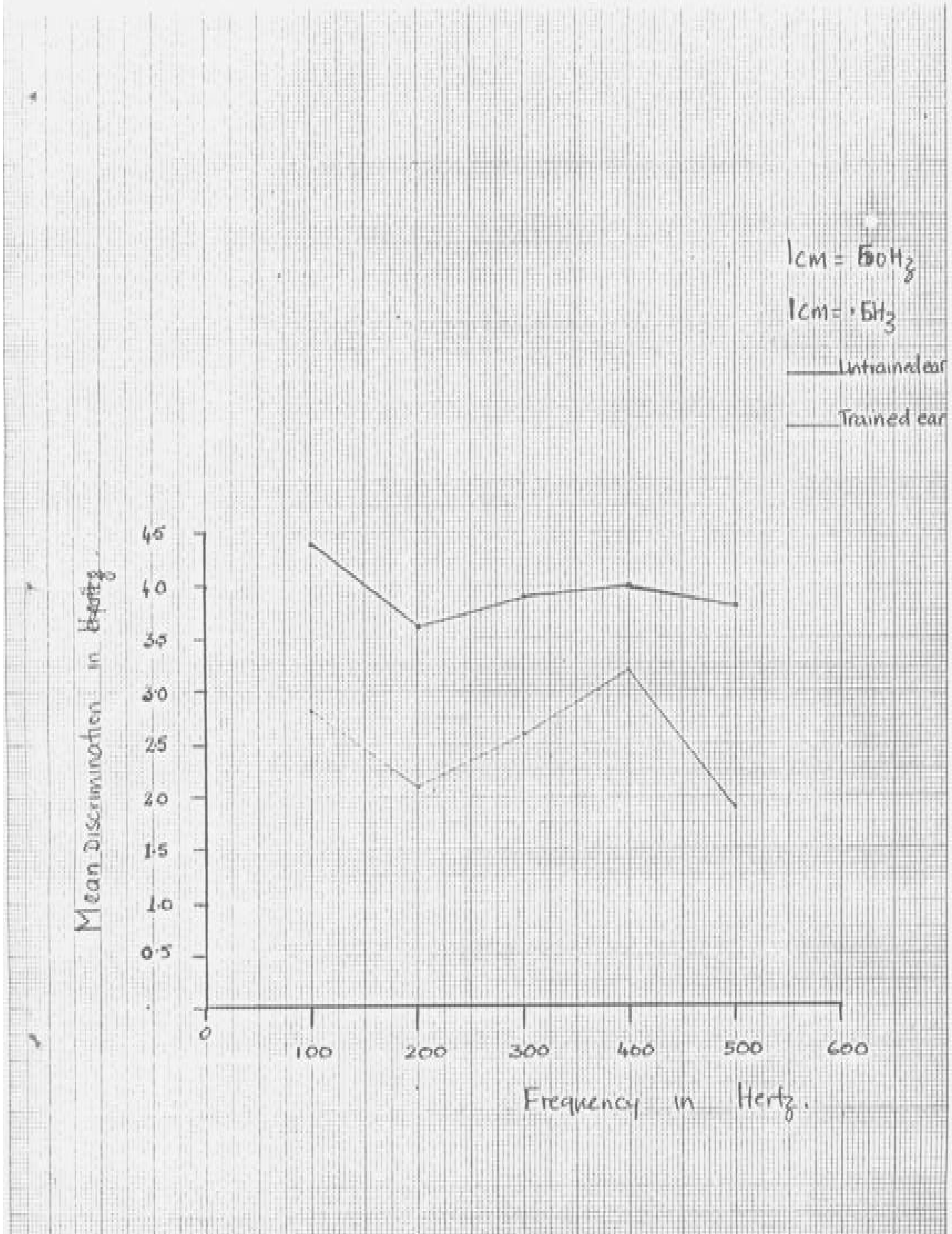
Applying the test of significance, it was seen that there was no significant difference on the test as a whole between dysphonics and normals as a group. This was seen at .01 and at .05 levels of significance.

Hence hypothesis (1) that “there is no difference between normals and dysphonics in their ability to discriminate frequencies” is accepted.

Further, the test of significance also indicated that there is a difference between male dysphonics and females dysphonics, with female dysphonics performing better on this task.

Davis and Boone’s (1967) study, using the Seashore Measures indicate that there is no difference in frequency discrimination between normals and dysphonics. The present experiment reveals a similar finings in spite of the different methods used.

Eisenson et al also using the Seashore Measures concluded that voice patients were inferior to normals in frequency discrimination. There results are neither in according with those of Davis and Boone (1967) nor with the results of the present experiment. This discrepancy in the finings, as stated by Davis and Boone may be due to differences in control and experiment groups, and the scoring methods.



1cm = 50Hz
1cm = ·5Hz
Untrained ear
Trained ear
Mean Discrimination in Hertz
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
100
200
300
400
500
600
Frequency in Hertz.

Experiment II (d)

Comparison of frequency discrimination between people trained in music and the untrained

The means and S.D.'s of these groups have been computed and is given in table VIII. The mean values are also shown in graph VI and the raw data in appendix II.

Table VIII showing the mean and S.D. of people trained in music and those untrained

Freq in Hz	Trained (T)/ Untrained(Ut)	Means	S.D.	
100	T	2.80	15.08	
	Ut	4.4	25.99	
200	T	2.1	11.49	
	Ut	3.6	21.30	
300	T	2.6	14	
	Ut	3.9	22.68	
400	T	3.2	17.23	
	Ut	4.0	23.32	
500	T	1.9	10.42	
	Ut	3.8	22.32	
Mean on whole Test (Trained)		2.5	S.D. on whole Test (trained)	11.61
Mean on whole Test (Untrained)		3.9	S.D. on whole Test (untrained)	23.18

Examination of this table reveals that the means for all five frequencies taken independently are lower in the trained group, indicating better performance on this task. The performance on the test as a whole of the trained group also shows a similar findings.

The table also reveals that the untrained are move variable on the test as a whole, and also on all the five test frequencies.

Further statistical analysis indicate the following Z values.

Table IX showing Z values of people trained in Music and those untrained

Freq. in Hz	Z values	Levels of Significance	
		.05	.01
100	2.44	A	A
200	2.10	A	A
300	1.831	R	A
400	1.497	A	A
500	2.931	R	R
On whole test	3.655	R	R

According to this table H_0 is accepted at 100 Hz, 200 Hz, and 400 Hz, and rejected at 300 Hz and 500 Hz at .05 level. At 0.01 level, the hypothesis is accepted at all frequencies except at 500 Hz.

The test of significance, when applied to the test as a whole, showed that there is a significant difference between the trained and untrained groups in frequency discrimination task. The means of the trained group are lower, and hence frequency discrimination is better in the trained, compared to the untrained. The hypothesis (4) “that there is no difference in frequency discrimination ability between people trained in music and those untrained” is rejected. The results of this experiment supports Lagenbeck’s (1965) statement that “the musician differentiate pitch better than non-musical subjects”. The results are also in agreement with Hirsh’s (1952) finings on a similar study.

Reliability Test

To check the reliability, test-retest method was used. The significance of difference between scores of the two tests were computed for each frequency. There was no difference between the test and retest scores at .01 level and hence the test scores were considered reliable, for the normal group.

The reliability test was also done on the dysphonic group and scores were also found to be reliable.

In summary it can be stated that:

1. There was no difference in discrimination between right and left ears and hence hypothesis (3) is accepted.

2. There was a significant difference between males and females, in their ability to discriminate, so hypothesis (2) is rejected.
3. Hypothesis (1) is accepted, as there was no difference in frequency discrimination among normals and dysphonics.
4. Hypothesis (4) is rejected, as there was a significant difference between people trained in music and those untrained

An attempt, was made to test frequency operated discrimination, using two frequency generator operated manually and a pulse circuit. Since this method posed several problems, tape recorded material was used. Using the tape recorder, as an alternate method has been suggested by Lagenbeck (1965); and also used by Madsen et al (1969). At this point, it seems relevant to note Madsen et al statement regarding the equipment, selection and presentation of stimulus.

> “Auditory researchers who spend most of their time laboriously selecting and preparing control stimulus presentations are understandably suspect of faulty equipment and /or unspecified parameters of investigation. Indeed, stimulus presentations as well as selection of subjects, is the paramount aspects of consideration”.

It was also felt, after this experiment that using tape recorder, is a simpler method as suggested by these authors.

It was observed, in this study that, some subjects, could discriminate frequencies, even at the no difference level (i.e., eg., 100 Hz and 100 Hz). Bergeijik et al (1958), Denes and Pinson (1973) state that for sounds of moderate level, one can detect a change of pitch of about 3 cps, for frequencies below 1000 Hz. In the present study, it was found that the discrimination, for frequencies in the range of 100 – 500 Hz, did not show statistically significant variation, between frequencies in both males and females. The mean discrimination ranged from 2.6 to 3.6 in males and from 3.6 to 4.4 in females.

Attempts have been made to establish a criteria, for normal frequency discrimination. West et al state that “a tone deafness with a limit of 15 cps or more may be regarded positively as the causes for monotomy of speech”. Anderson (1961), states that, an individual may be regarded as having poor frequency discrimination when the limit of his discrimination is 9 cps or more.

It was noted in this study that normals could detect changes ranging from 0 – 10 Hz in males and 0 – 12 Hz in females.

This range coincides with that, stated by the earlier authors. The assumption that dysphonics may have poor frequency discrimination is not supported by the results of the present study. Davis and Boone (1967) have concluded that voice patients are probably similar normals in their ability to discriminate pitch. This seems to hold good, for the present study which indicates 71.4% overlap of the two groups in this task.

The claim that poor frequency discrimination could be one of the possible causes of dysphonia may be questioned. This finding also questions the need for training in frequency discrimination in dysphonics.

Ludin (1963) states that:

“ .. . . . .pitch discrimin is behaviour which is not merely a functions of a sense organ as was previously presumed, but behaviour of a discriminative sort developed through interaction with stimulus objects. This behaviour is subject to change and improvement through casual learning or by means of a continued situation where a prepared series of training procedures is prescribed”.

This study has shown a significant difference between the people trained in music and those untrained. Kuper (1972) concludes from his study that, there is a relationship between musical ability and speech correctability, and recommends speech training through musical ear training could be given for children with ‘pitch deficiency’ who had articulatory defects.

Training in frequency discrimination, could lead to improved performance in this aspect. Gengel (1969) states that small DL’s were found after limited practice for low frequencies, which should be encouraging for teachers of the deaf, especially in the teaching of intonation. Eisenson, et al found that, their group of dysphonics tested before and after completing a program of voice training emphasizing ear training in pitch discrimination showed a significant gain in pitch discrimination. However, it has not been found if training in frequency discrimination, would lead to improved voice, though it has been recommended by several authors (Van Riper, 1963, Eisenson et al, 1958, Davis and Boone, 1967, Anderson 1961). Thus from the results and review of literature, of this study, it can be concluded that training may improve frequency discrimination, but its usefulness in voice therapy may be questioned.

CHAPTER V

SUMMARY AND CONCLUSIONS

The present study was aimed at comparing the frequency discrimination ability between normals and dysphonics, in an Indian population. It was also intended to see if people trained in music would have better discrimination.

Five frequencies ranging from 100-500 Hz were selected as test frequencies. Pairs of tones (one followed by another) differing only in frequency were tape recorded, and this was used as the test material. Duration of each tone, remained a constant of 2.8 secs, having equal intensity. A total of 20 pairs of tones were recorded for each frequency. The test material was fed through the head set of an audiometer worn by the subjects.

The subjects were instructed to indicate, when they could make a difference between the two tones or the pair. The material was presented at a sensation level of 40 dB. Total time taken for the complete test was about 8 minutes.

The results were statistically analyzed and the following conclusions were drawn:

Conclusions

1. There is no significant difference between the right and left ears in discriminating frequencies in the range of 100 – 500 Hz.

2. There is a statistically significant difference between sexes in this discrimination task.
3. (a) There is a significant difference between normal males and females with males evidencing better performance.

   (b) In the dysphonic group, the females show better discrimination.

4. Between frequencies, both sexes show no differences in discrimination in the frequency range (100 – 500 Hz).
5. Some individuals consider two tones as being different in spite of the frequency, intensity and duration being constant.
6. No significant difference is seen between normals and dysphonics as a group on frequency discrimination task. However, a significant difference in this ability is found between normal and dysphonic males, with normal males evidencing better.
7. Normals (Males and Females) were able to differentiate frequencies within a difference of 12 Hz.
8. 28.5% of dysphonics were able to discriminate, frequencies only beyond a difference of 12 Hz.
9. A significant difference is seen between people trained in music and the untrained.

Recommendations for further studies

1. The test may be tried on a larger population
2. A study of frequency discrimination in different speech problems like misarticulation, may be done

3. The relationship between the age and frequency discrimination may be studied.
4. A study of the effect of frequency discrimination training in voice therapy, may be tried.
5. Effect of frequency discrimination training on deaf and hard of hearing cases in teaching speech and language may be done.
6. It may be interesting to study the effect of training on discrimination ability

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APPENDIX – I

A.F. Generator (Philips)

The Philips GM 2308/90 is a generator operating in the Oto 16,000 c/s frequency range. It comprises of oscillations, both variable in frequency, one from 85 to 100 Kc/s, the other from 100 to 101 KC/s. The two oscillator output voltages are mixed, the results output signal frequency being variable between 0 and 16,000 C/s.

Technical Data

When the properties are expressed in numerical values with statements of tolerance, they are guaranteed values. The data without statement of tolerances are only given for guidance and apply to the average apparatus.

Frequency Counter – Type 702

Manufactured at Indian Telephone Industries, Bangalore.

Introduction and Specification

The digital frequency counter, Type 702 is a portable instrument designed to make direct frequency and period measurements up to a maximum frequency of 1 MH2.

High accuracy in measurement is obtained by an internal

Crystal Oscillator, which could be further improved by housing it in a temperature controlled oven.

The frequency counter is completely transistorized to have low power consumption, low heat generation and portability, plug-in printer card construction is employed for ease of servicing and maintenance.

Measurements are displayed by 6 mm. charact illuminated by filament lamps arranged in a ‘ladder’ pattern. The controls are very simple so that the counter can be operated by semi skilled persons. Self-check facility is provided.

Hearing Aid Test Box (Hruel and Kjaer Type 4217)

Hearing Aid Test Box Type 4217 consists of a miniature anechoic enclosure with a built-in loudspeaker and a transistorized oscillator and amplifier section. The anechoic enclosure is set up with thick layers of glass wool to obtain essentially free field conditions. The anechoic enclosure of Hearing Aid Text Box was used in this study, to keep microphone and of Tape Recorder, and speaker from R.F.C. (type 1022) through frequency analyzer.

Frequency Analyzer (Bruel and Kjaer Type 2107)

The type 2017 is an A.C. operated, audio frequency of the const. percentage bandwidth type. It has been designed, especially as a narrow band sound and vibration analyzer but may be used for any kind of frequency analysis and distributed measurement within the specified frequency range. It is supplied with the weighting networks for sound level measurements 'A' 'S' and 'C' and a 7-pin input socket for connection of S & K condensor microphone or preamplifier as required.

The instrument is supplied with an output switch, by means of which the rectifier and meter circuit can be switched to measure either the peak, the arithmetic average or the tune RHS value of the input signal.

Beat Frequency Oscillator – (Bruel and Kjaer Type 1022)

BFO Type 1022 is a precision signal generator using solid state circutary throughout. It covers the range 20 – 20,000 Hz and is designed for acoustical, Vibrational and electrical measurements.

The 1022 works on the heterodyne principle using two high frequency oscillators one of which operators at a fixed frequency while the frequency of the other can be varied. The required audio-frequency is then obtained by mixing these frequencies to produce beat frequency provision is made, for varying the frequency in steps of 2 Hz.

The output impedance can be varied to give maximum power (2.5) in a load of 6 – 60 – 600 -6000.

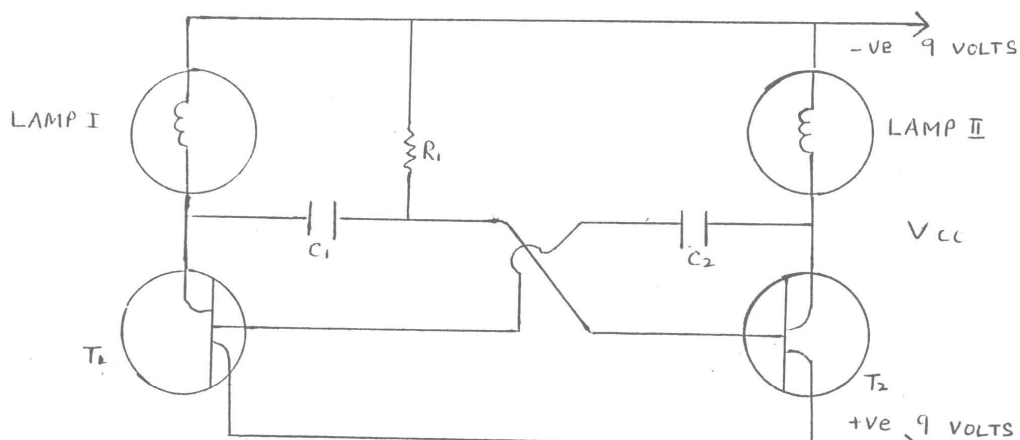
A compressor amplifier can be switched in, to control the regulating amplifier so that constant output level is obtained.

Level Recorder (Bruel and Kjaer Type 2305)

Level Recorder Type 2305 has been designed for accurate recording of signal levels in the frequency range 2 Hz to 20 HK Hz. Typical fields of application are the recording of frequency response characteristics, revibration decay curves, noise and vibration levels, spectrograms, and polar diagrams.

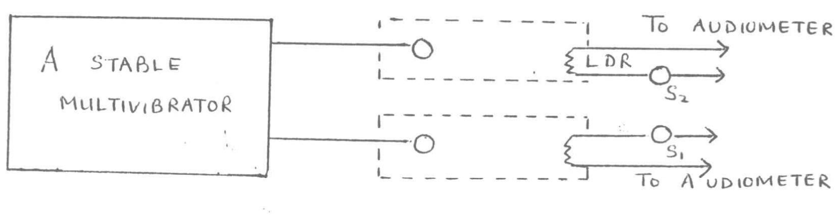
Recordings can be made by means of ink either on lined paper or on frequency calibrated paper, or by means of a sappheri stylus on wax-coated paper. A synchronous motor is used for the paper drive, and by means of a gear-box 12 difference paper speeds are available. The operation of the Recorder is based upon the servo principle.

Electronically the Recorder Type 2305 mainly consists of an input circuit, a Range Potentiometer, a direct-coupled A.C. input amplifier, the special B & K signal rectifier arrangement and a D.C. output amplifier section which drives the electrodynamics writing system.



$R_1 = R_2 = 10\,k$ $L_1 = L_2 = 6.3\,v.$

$C_1 = C_2 = 250\,\mu f$ $T_1 = T_2 = AC\,128$



Beltone 12-D Portable Manochannel Audiometer

It has provision for tape input apart from speech and pure tone audiometry.

Telefunken Tape Recorder

Is a two channel Tape Recorder with counter.

Pulse Circuit

The switching circuit consists of a simple stable multi vibrator light flasher. It is developed in the electronics Lab. of the Institute. The two lights shown in the circuit block diagram flashes alternatively for time ‘t’ sec. The time period is fixed by choosing appropriate values of resistor and capacitor. The two lights are fixed with two LDR’s (light dependent resistors) independently in light proof enclosure.

These tow LDR’s conducts alternately for a fixed interval of time. The two LDR’s are connected in series with the two signals under test as shown in the figure. The conduction of a particular signal takes place only during the presence of light on a particular LDR, resulting the facility of presenting the two signals alternately for a period of three seconds approximately.

APPENDIX II

Data showing frequency discrimination in normal females

Freq./Sl.No.	100	200	300	400	500
1	4	2	2	2	2
2	8	6	4	8	10
3	2	2	0	2	2
4	2	2	6	4	4
5	4	4	6	4	4
6	6	6	2	2	4
7	2	2	2	2	0
8	6	6	2	4	4
9	6	2	4	4	4
10	4	4	2	2	2
11	8	4	2	4	2
12	2	2	8	4	4
13	2	4	8	6	4
14	8	4	2	2	4
15	4	2	2	2	2
16	8	2	2	2	2
17	2	4	4	6	6
18	8	6	4	8	6
19	6	6	2	6	2
20	6	8	6	6	6
21	2	0	2	2	2
22	8	4	6	2	2
23	4	2	10	2	4
24	4	4	2	6	2
25	2	2	2	2	0
26	2	2	2	4	2
27	2	4	4	4	2
28	4	2	4	6	4
29	4	2	4	2	6
30	2	2	2	2	2
31	6	6	8	6	2
32	2	0	2	2	6
33	10	12	6	6	4
34	2	12	4	8	6
35	4	6	8	6	12

Data showing frequency discrimination in normal males

Freq./Sl.No.	**100**	**200**	**300**	**400**	**500**
1	2	4	10	10	2
2	4	4	2	2	4
3	2	2	2	2	2
4	4	2	2	4	2
5	2	2	0	2	4
6	2	2	2	4	2
7	4	2	2	2	4
8	2	2	2	2	2
9	4	2	2	4	2
10	4	2	4	4	4
11	2	2	2	4	2
12	4	4	4	2	2
13	6	6	4	4	8
14	4	2	2	2	4
15	2	2	2	2	0
16	2	2	4	2	4
17	2	2	0	4	8
18	10	0	0	6	2
19	2	2	0	2	4
20	4	4	6	6	4
21	2	2	2	4	4
22	4	8	4	4	2
23	4	0	2	6	4
24	2	0	4	2	4
25	6	2	0	8	0
26	2	4	10	0	4
27	4	4	2	0	0
28	6	6	0	2	2
29	4	2	0	0	0
30	4	6	2	2	0

Data showing Frequency discrimination in Dysphonic Males

Freq./Sl.No.	**100**	**200**	**300**	**400**	**500**
1	6	8	16	8	6
2	18	6	8	4	4
3	20	14	10	6	20
4	4	4	6	2	8
5	2	8	6	2	4
6	2	6	0	2	4
7	4	6	2	4	2
8	4	4	2	2	4
9	2	2	2	0	4
10	8	6	4	2	6
11	4	6	2	14	6
12	18	10	8	8	12
13	18	14	14	20	12
14	4	10	4	4	6
15	0	0	0	0	0
16	4	4	0	2	2
17	2	2	2	4	2
18	2	2	2	4	2
19	2	4	4	2	2
20	2	2	2	0	4
21	4	10	4	2	6

Data showing frequency discrimination in Dysphonic Females

Freq./Sl.No.	**100**	**200**	**300**	**400**	**500**
1	16	8	4	2	4
2	4	4	2	10	12
3	14	10	6	6	10
4	4	6	2	2	2
5	10	4	4	4	4
6	6	4	2	2	8
7	2	2	0	4	0
8	2	2	2	4	0
9	2	4	4	2	2
10	2	2	2	4	4

Data showing the frequency discrimination of people trained in Music

Freq./Sl.No.	100	200	300	400	500
1	0	0	2	2	2
2	2	2	2	2	2
3	0	0	2	2	0
4	2	0	0	2	2
5	6	4	6	2	4
6	4	6	6	4	6
7	0	0	2	2	0
8	0	4	4	2	4
9	2	2	0	2	0
10	2	4	4	2	0
11	2	0	2	4	2
12	2	2	0	4	0
13	4	2	2	2	2
14	4	0	2	6	4
15	2	2	2	0	2
16	4	4	0	4	0
17	4	4	4	6	2
18	6	2	0	6	2
19	6	0	4	4	2
20	2	2	2	4	4
21	2	4	4	2	2
22	2	4	4	2	2
23	2	6	4	4	2
24	2	2	2	4	0
25	4	4	6	6	8
26	4	0	0	2	0
27	2	2	4	2	0

Data showing the frequency discrimination
of Right and Left ear is males

Sl.No.		100	200	300	400	500
1	R	2	4	10	10	10
	L	2	2	4	2	4
2	R	2	2	2	2	2
	L	2	4	2	4	4
3	R	4	2	2	6	0
	L	10	2	2	4	2
4	R	2	2	0	2	4
	L	2	2	2	4	2
5	R	2	2	2	4	2
	L	4	2	2	2	2
6	R	4	2	2	4	2
	L	2	2	4	6	2
7	R	2	4	4	4	2
	L	2	2	2	4	6
8	R	2	2	2	4	2
	L	2	4	2	2	0
9	R	4	4	4	2	2
	L	2	2	2	2	4
10	R	6	6	4	4	8
	L	2	4	2	0	8
11	R	4	2	2	2	4
	L	2	0	2	2	4
12	R	2	2	2	2	0
	L	0	4	2	2	4
13	R	4	2	2	4	2
	L	2	2	4	6	2

Data showing the frequency discrimination of Right and left ear in females

Sl.No.		100	200	300	400	500
1	R	4	2	2	2	2
	L	4	2	4	2	2
2	R	8	6	4	8	10
	L	6	6	6	8	4
3	R	4	4	2	2	2
	L	4	2	2	2	2
4	R	2	2	0	2	2
	L	2	2	4	6	2
5	R	2	2	6	4	4
	L	2	2	4	2	2
6	R	4	4	6	4	4
	L	2	4	2	6	0
7	R	6	6	2	2	4
	L	4	2	4	4	2
8	R		2	2	2	0
	L		2	2	2	2
9	R	6	6	2	4	4
	L	2	4	6	2	4
10	R	2	2	8	4	4
	L	4	4	2	6	4
11	R	2	4	8	6	4
	L	4	4	4	6	2
12	R	8	4	2	2	4
	L	6	2	2	2	4
13	R	4	2	2	2	2
	L	2	2	4	4	2
14	R	8	2	2	2	2
	L	10	2	2	2	2
15	R	2	4	4	6	6
	L	6	6	6	2	2

Table cont………

16	R	8	4	6	2	2
	L	4	2	4	2	4
17	R	4	2	10	2	4
	L	2	2	4	4	2
18	R	4	4	2	6	2
	L	4	4	2	4	4
19	R	2	2	2	2	0
	L	2	2	2	2	2
20	R	2	2	2	4	2
	L	0	4	0	2	2
21	R	8	6	4	8	6
	L	2	2	6	2	2
22	R	6	6	2	6	2
	L	2	2	6	2	2
23	R	6	8	6	6	6
	L	8	4	6	4	6
24	R	4	2	4	6	4
	L	2	2	2	8	4
25	R	4	2	4	2	6
	L	2	2	4	2	8
26	R	2	2	2	2	2
	L	2	2	4	4	2
27	R	6	6	8	6	2
	L	6	2	6	2	4