ACOUSTIC ANALYSIS OF THE SPEECH IN NORMAL ADULTS

Register No. 8403

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to the University of Mysore.

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MYSORE - 570 006.

MAY—1986

TO ALL MY TEACHERS,

BOTH FORMAL AND

INFORMAL, TO WHOM

I OWE MORE THAN WHAT I

KNOW

CERTIFICATE

This is to certify that this Dissertation entitled: ACOUSTIC ANALYSIS OF THE SPEECH IN NORMAL ADULTS is the bonafide work in part fulfilment for degree of M.sc., speech and Hearing and of the student with the Register Number 8403.

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DECLARATION

I hereby declare that this dissertation entitled ACOUSTIC ANALYSIS OF THE SPEECH IN NORMAL ADULTS is the result of my own study under the guidance of Mr.N.P.Nataraja, Reader and Head of the Department of Speech Sciences, All India Institute of Speech and Hearing, Mysore and has not been submitted earlier at any University for any other diploma or degree.

Register No.8403

Mysore

Dated: May 1986.

CERTIFICATE

This is to certify that this Dissertation entitled: ACOUSTIC ANALYSIS 0F THE SPEECH IN NORMAL ADULTS has been prepared under my supervision and guidance.

N.P.Nataraja
Reader and Head of
the Dept. of Speech science.

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CHAPTER-I

INTRODUCTION.

"The past two decades have been wittnessed to an increasing application of acoustic analysis to the study of speech development children" (Kent, 1976). Some times the physiologic and phonetic interpretation of acoustic data are uncertain, but acoustic analysis i.e. appropriate to test certain hypothesis about changes in anatomy, motor control and phonological function as a function of age.

In rehabilitating the various communication disordered individuals, diagnosis of plays an important role. Knowledge of "normal" condition is prerequisite for diagnosis. It has become a tradition to compare a disordered individual with a comparable normal individual. This helps in recognizing the differences between the two and later to understand the disorder according to the type of differences. This would also help in deciding the direction and strategies for therapy. This tradition calls for studies which deal with changes with the age, in various acoustic aspects of speech in the normal population.

The existing data on the acoustic properties of adults speech are all too sketchy in nature, but they hold the promise of sensitive methods for study of changes of speech as a function of age and disorders.

Statement of the problem: The problem was to know how the acoustic parameters vary with the age and sex.

The present study therefore aims at analyzing some of the acoustic aspects of the speech of adults. Hirano (1981) has listed a number of parameters of voice. Some of these have been considered in this study, namely, speaking fundamental frequency, frequency range in speech, intensity range in speech, rise and fall time of speech. In addition the intensity levels of harmonic and vowel duration have also been studied.

One hundred adults, both males and females, age ranging from sixteen to sixty five years, were considered for the study. All the subjects were normal interms of speech, language and hearing and subjects did not had any respiratory, laryngeal, pharyngeal or oral cavity abnormalities.

Recordings of three repetitions of sentences "Idu pa:pu" "Idu ko:ti" and "idu kempu banna" were made for all the subjects. These were analyzed to obtain the following parameters i.e.

1. The speaking fundamental frequency
2. The frequency range of speech
3. The intensity range of speech
4. The rise time of speech
5. The fall time of speech
6. Duration of the vowel /i/ and "idu".
7. The intensity levels of harmonics.

The measurements were made using an high resolution signal analyzer (B&K 2033) and a pitch analyzer (PM-1OO).

The obtained data were than subjected to statistical analysis to verify the following hypothesis i.e. "There is no significant difference in acoustic parameters with increase in age and between males and females.

Auxillary hypotheses:

I(a) There is no significant difference in speaking fundamental frequency between males and females of the same age group.

I(b) There is no significant change in speaking fundamental frequency with increase in age in males.

I(c) There is no significant change in speaking fundamental frequency with increase in age in females.

II(a) There is no significant difference in the frequency range ia speech betweaa males and females of same age group.

II(b) There is no significant difference in the frequency range in speech with increase in age in males.

II(c) There is no significant difference in the frequency range ia speech with increase in age in females.

III(a) There is no significant difference in the intensity range in speech between males and females of the same age group.

III(b) There is no significant difference in the intensity range in speech with increase in age, in male.

III(c) There ia no significant difference in the intensity range ia speech with increase ia age, in females.

IV.(a) There is no significant difference in the ratio of the (µ parameter)intensities at which the harmonics occur above l000Hz to that below l000Hz between males and females of the same age group.

IV(b) There is no significant difference in ratio of the intensities at which harmonics occur above l000Hz to that below l000 Hz.(µ-parameters)with increasing age, in males.

IV(c) There is no significant difference in ratio of the intensities at which harmonica occur above l000Hz to that below l000 Hz ((µ-parameters) with increasing age, in females.

V(a) There is no significant difference in the rise time of speech between males and females of the same age group.

V(b) There is no significant difference in the rise of speech with increase in age in males.

V(c) There is no significant difference in the rise of speech with increase in age, in females.

VI(a) There is no significant difference in the fall time of speech between males and females of the same age group.

VI(b) There is no significant difference in the fall time of speech with increase in age* in males.

VI(c) There is no significant difference in the fall time of speech with increase in age,in females.

VII(a) These is no significant difference in the vowel duration between males and females of the same age group.

VII(b) These is no significant difference in the vowel duration with increase in age, in males.

VII(c) There is no significant difference in the vowel duration with increase in age, in femals.

Definition of terms:

1. Speaking fundamental frequency:

The man frequency of the speech stimulus displayed.

2. frequency range in speech

The difference between the highest and the lowest frequency for the speech stimuli.

3. Intensity range in saaech:

The difference between the highst and the lowest intensities in the speech stimuli.

4. µ - Parameters:

The ratio of the intensity levels of the harmonics between l-2KHz to the intensity levels below l000Hz, as shown by the high resolutiopn sign analyzer.

5. Rise time of Speech:

The difference in centiseconds between the initiation of speech and the time at which speech becomes steady, in terms of the intensity.

6. Fall time of speech:

The differ ace in centiseconds between the time at which the intensity curve began to decreases and the termination of speech.

7. Vowel duration:

The duration from the beginning of the vowel to the beginning of the following stop as shown by the High Resolution Signal Analyzer.

Limitations of the study:

1. The number of subjects in each age group ia 10 males and 10 females only.
2. Only repeat after me "Speech samples'* are uaed for the study.

Implications of the study:

This study provides information regarding the changes in speeking fundamental frequency, frequency range in apeech, intensity range in speech, rise time and fall time of speeeh, intensity at harmonica and vowel duration, as a function of age, in the age range of 16-65 years both in case of males and females.

It also provides information regarding the difference in above parameters between males and females.

This study further provides information in the above mentioned parameters in normal adults inthe age range of 16-65 years., against Which the variation in these parameters on a clinical population may be useful in differential diagnosis of voice disorders. The information obtained from this study may be useful in speaker identification.

CHAPTER-II

REVIEW OF LITERATURE

"The one form of communication which people use most effectively in interpersonal relationships is speech. With it, they give form to their innermost thoughts. Without it, they are reduced to animal noises and unintelligible gestures. In a real sense, speech is the key to human existence* (Fisher, 1975).

Speech is produced without observable effort by the human-beings. The range of speech variation is immense, and yet considered normal.

Only a small part of the information is conveyed by speech less than l%of this is used for linguistic purposes, as such the rest gives other kinds of information, about the specific character of the vasal tract of the speaker, which enables one to recognize speaker's voice, physical well being and emotional stated attitude towards the entire context in which the speech event occurs. It can also carry other information about speaker with reference to the conventions of social class occupation and style.

The spoken utterance is an impact on the atmosphere, very short duration and on a very small scale, in which the component sounds die away at different distances depending on their inherent energy. But these vibrations are of at most complexity.

Acoustic analysis resolves this tortuous oscillation in a three dimentional frame work of frequency, intensity and time in which each sound is characterized by a typical display of energy in various frequency regions along the unlimited time axis (Cotz, 1961).

The crucial event essential for voice production is vibration of vocal cords. It changes DC air stream to AC air stream. Converting aerodynamic energy to acoustical energy. From this point of view the parameters involved in the process of phonation can be divided into 3 major groups.

(1) The parameters which regulate the vibratory pattern of vocal folds;

(2) The parameters which specify the vibratory pattern of the vocal folds;

(3) The parameters which specify the nature of sound generated.

Hiraha (1981) has further elaborated on this, by stating that, "the parameter Which regulate the vibratory pattern of the vocal folds can be divided into two groupst Physiological and Physical. The physiological factors are succinftty put, related to activity of the respiratory, phonatory and articulatory muscles. The physical factors include the expiratory force, the conditions of vocal folds and the state of the vocal tract. The expiratory force is the energy source of phonation and is regulated chiefly by the respiratory muscles and the stake of the brancho pulmonary system and thoracic cage. The condition of the vocal folds which are the vibrators is described with respect to the position shape, size, elasticity and viscosity of the vocal folds. It is influenced by the activity of laryngeal muscles and pathological conditions of the vocal folds and the adjacent structures. The state of the vocal tract, the channel between the glottis and lips affects the vibratory pattern of the vocal folds to a certain extent and it is regulated chiefly by the articulatory muscles.

These primary physical factors inturn determine certain secondary features, which include the pressure drop across the glottis, volume velocity or mean air flow rate, and glottal impedance. These secondary features are referred to as the aerodynamic parameters.

Vibratory pattern of the vocal folds can be described with respect to various parameters including the fundamental frequency, regulatory of periodicity in successive vibrations, symmetry between the two vocal folds, uniformity or homogenity in the movement of different points within each vocal fold, glottal closure during vibration, amplitude of vibration, speed of excursion, wave which travels on the mucosa, contact area between the two vocal folds, glottal area wave form and so on.

The nature of sound generated is chiefly by the vibratory pattern of the vocal folds. It can be specified both in acoustic terms and in psychoacoustic terms. The psychoacoustic parameters are naturally depend upon the acoustic parameters. The acoustic parameters are, fundamental frequency, intensity, wave form or acoustic spectrum, and their time-related variations".

Hirano (1981) has pointed out that the acoustic analysis of the voice signal may be one of the most attractive methods for assessing phonatory function or laryngeal pathology because it is non-invasive and provides objective and quantitative data. The technique of acoustic analysis has promising future as a diagnostic tool in the management of voice disorders. Many acoustic parameters, derived by various methods, have been reported to be useful in differentiating between pathological voice and normal voice. Hirano (1981) goes on to say that all the previous reports are preliminary reports and that further extensive basic and clinical research is require in order to obtain some algorithm for diagnostic purpose.

Further, clinician will not really know what to expect with a medical diagnosis having a complete physical description of the larynx together with some objectives like "hoarse" or "rough", until he actually sees the case (Michel and Wendhl, 1971), on the other hand, if the clinician receives a report which includes measures of frequency ranges, respiratory function, fitter, volume-velosity of air flow during phonation, etc., in the form of a voice profile, the clinician can then compare these valuta to the norms for each one of the parameters and thus have relatively good ideas to how to proceed with therapy even before seeing the patient. Moreover, periodic measurement of these parameters during the course of therapy may well provide a useful index as to the success of the treatment.

Therefore, the present study aims at investigating some acoustic (mean fundamental frequency, in speech, mean intensity, frequency and intensity range in speech, fluctuations in intensity and frequency, rise, fall time of speech, harmonics, vowel duration) aspects of speech of Indian adults.

2.6 Speaking Fundamental Frequency;

In daily life, man communicates through speech. An evaluation of the fundamental frequency in phonation, may not represent the true fundamental frequency, used by an individual in speech. Hence, it becomes important to evaluate the speaking fundamental frequency.

The speaking fundamental frequency is estimated subjectively by matching or it is determined objectively with a pitch meter or Digipitch. For more precise measurement, fundamental frequency histograms are obtained with the aid of a computer.

Many investigators have studied the speaking fundamental frequency as a function of age and in various pathological conditions.

Michel, Hollien and Moore (1965) studied the speaking fundamental frequency characteristics of 15, 16 and 17 years old girls, in order to determine the age at which adult female speaking fundamental frequencies are established. Their results indicated that female attain adult speaking fundamental frequencies by fifteen years of age. It seems necessary, therefore, to study speaking fundamental frequency in girls of fourteen years of age and younger, in order to determine when adult frequencies are first evidenced (Michel, Hollien and Moore, 1965).

Kushal Raj (1983) studied the speaking fundamental frequency as a function of age, in children between 4 to 12 years. He reported that the fundamental frequency, both in case of males and females, decreases with age, males showing a sudden decrease around eleven years of age. No significant difference in fundamental frequency was found until the age of eleven years between males and females. The fundamental frequencies of the vowels /a/, /i/, /u/ /e/ and /o/, occuring in speech indicated that the fundamental frequency of vowel /a/ was the lowest in both males, and females /u/ was the highest for males and /i/, the highest for females,

The age dependent variations of mean fundamental frequency reported by Bohime and Hecker (1970) indicate that the mean speaking fundamental frequency decreases with age upto the end of adolescence. A marked lowering takes place during adolescence in men. In advanced age, mean fundamental frequency becomes higher in men but slightly lowered in women.

Hudson and Holbrook (1981) investigated the mean modal fundamental frequency, in reading, in two hundred young black adults whose age ranged from 18 to 29 years, and found it to be 110.l5Hz in males and 193.10 hz in females. Compared to a similar white population studied by Fitch and Holbrook(1970) and found that the black population had lower mean modal frequencies.

The mean speaking fundamental frequency of males age range from 20 to 89 years, indicated that progressive lowering of speaking fundamental frequency from age 20 to 40, with a rise in the level from age 60 through the eighties (Hollien and Shipp, 1972).

A study of the speaking pitch level in two groups of females, between 65 and 75 years and between 80 and94 years, indicated no significant difference in pitch level between the two groups. Therefore, the speaking pitch level of women probably varies little throughout adult life.

Many hearing impaired speakers are unable to control their speaking fundamental frequency. Meckfessel (1964) and Thornton (1964) reported speaking fundamental frequency data for 7- and 8- year old hearing impaired speakers that were higher than values for normal hearing speakers. Ermovick (1965) and Gruenewald (1966) reported values that were equal to or lower than values for normal hearing speakers.

Meckfessel (1964), Thomton(1964) reported speaking funda mental frequency values in postpubescent hearing impaired males that were higher than those obtained for normal hearing females, while Ermovick (1965) and Gruenewald (1966) reported values that were similar.

Gilbert and Campbell studied the fundamental frequency in three age groups (4 to 6 years, 8 to 10 years and 16 to 25 years) of yearing impaired individuals, and reported that the values were higher in hearing impaired groups when competed to values reported in the literature for normal hearing individual of same age and sex.

Duffy (1954) analyzed the speech of cerebral palsied individuals by means of an instantaneous fundamental frequency recorder. He detected pitch characteristics which were related to different types of cerebral palsy.

The speaking fundamental frequency characteristics of institutionalized mongoloid girls, between 8 and 11 years were studied by Hollien and Copeland (1965). Their results showed that mongoloid girls do not exhibit abnormally low speaking fundamental frequency level but rather possess vocal frequency characteristics generally similar to those of their age peers even though they are retarded with respect to physical size. These results agree with those of Michel and Carney (1964).

However, the above findings do not support the clinical observations of McIntire and Dutch(1964), Strazzula (1953) and Benda (1949) suggesting that the voices of children with mongolism are substantially lower in voice fundamental frequency than those of normal children.

Contrary to this, Weinberg and Zlatin (1970) reported that, the mean fundamental frequency level for the sample of children with mongolism, studied by them, was significantly higher than the mean fundamental frequency level for the control group. In 1974, Montague, Brown and Hollien supported the above findings. Their results indicated that while isolated Down's syndrome children had relatively higher fundamental frequencies, as a group no difference was found between Down's syndrome and intellectually average children for that parameter. Further no relationship was found within the down's syndrome group between speaking fundamental frequency and I.Q.

Weinberg et.al (1975) described selected speech characteristics of patients with acromegaly. Some of the patients with acromegaly were found to use a lower fundamental frequency than the normals. This lower fundamental frequency was prominent in female acromegalies than in male acromegaalies.

Studying the mean speaking fundamental frequency in Stutterer and nonstutterers, Healey (1982) reported no significant difference.

Investigation of the effects of smoking on the fundamental frequency of adult women was carried out by Gilbert and Weisman (1974). The results indicated that in the reading condition, fundamental frequency for the smokers was significantly lower than the fundamental frequency of the non-smokers.

Following this study, stoicheff (1981) controlled the smoking variable and found the speaking fundamental frequency to be higher relative to previous studies. He concluded that the speaking fundamental frequency of adult female is relatively stable until completion of the menopause, when it lowers. This lowered speaking fundamental frequency is maintained in aged women.

Burk and Saxman (1968) reported higher mean speaking fundamental frequency values among female Schizophrenics than that of the controls, but the difference was not significant.

Shipp and Hontlngton (1965) found no significant difference in the mean and median speaking fundamental frequency between laryngitic and postlaryngitic voices.

Murry (1978) studying the speaking fundamental frequency characteristics of four groups of subjects, namely vocal cord paralysis, benign mass lesion, cancer of larynx and normals. He noted that the parameters of mean speaking fundamental frequency failed to separate the normals from the three groups of pathologic subjects.

In parallel study, Murry and Doherty (1980) reported along with other voice production measures such as directional and magnitudinal pertubation, the speaking fundamental frequency improved the discriminant function between normal voices and malignancy of the larynx.

Sawashima (1968) reported a rise in mean speaking fundamental frequency in cases of sulcus vocalis and a fall in mean speaking fundamental frequency in cases of polypoid vocal cords and virillsm. Very high mean speaking fundamental frequency values result from disturbances mutation in males.

At present, mean speaking fundamental frequency is measured as a clinical test value (Hirano, 1981).

Rashmi's (1985) study on acoustic analysis of speech in children show that, there is little change in speaking fundamental frequency as a function of age in males upto 14 years, at Which age a sudden decrease in the speaking fundamental frequency was observed and very little change in speaking fundamental frequency was observed in females with increase age.

Thus review of literature shows that the measurement of fundamental frequency both in phonation and speaking is important in assessing the neuromuscular development and diagnosis and treatment of voice disorders. Few studies have been carried out to note the changes in fundamental frequency in Indian population with reference to age (Samuel, 1973) Usha,1978; Gopal, H.S., 1980; Kushal raj, 1983; Rashmi, 1985). However the present study is also considering the measurement of fundamental frequency as it would be helpful in assessing the earlier findings and also to find out relationship between fundamental frequency and other parameters that are considered in the present study as all the parameters are measured on the same population.

Frequency range in speech: Humans are capable of producing a wide variety of acoustic signals. Success in decoding acoustic speech signals assumed that the speaker will produce; (1) acceptable phonemes, variously sequenced or combined, (2) changes in the use of time, (3) change in fundamental frequency, and (4) changes in intensity or energy. These four comprise the basic elements of verbal communication (Brackett, 1971).

The patterned variations of speech over linguistic units of differing length (syllables, words, phrases, clauses, paragraphs), yield the critical prosodic feature, namely intonation (Freeman, 1982). In otherwords, during speech, the fundamental frequency of phonation varies. This range is called speech range or the speech frequency range (Hirano, 1981). Variations in fundamental frequency and the extent of range, Use also relate to the intent of the speaker as discussed by Fairbanks and Pronovast (1939). More specifically, the spread of frequency use corresponds to the mood of the speaker, that is, as Skinner (1935) reports, cheerful animated speech exhibits greater range use than serious, thoughtful speech. Changes in duration and fundamental frequency during syllable elements of words are basic to the melody and rhythm patterns unique to English. Steps syllables are perceived as being higher in pitch than unstressed syllable (Freeman, 1982).

Relatively little is known about developmental changes in the range or variability of fundamental frequency. Most of the literature on the new born infants cry appears to have the capability of extending this range appreciably in either direction. Ringle and Kluppe (1964) reported a range of 290-508Hz for ten infants aged 4 to 10 hours. Fairbanks (1942) observed a range of 153-888 Hz for an infant in the first month of life and a rang of 63-2631 Hz for first 9 months of life. MoGlone's (1966) investigation of children aged between 1 and 2 years revealed a total range of 16.2 tones, or about two octaves. Van Oordt and Drost (1963) concluded from a study of 126 children in two age groups (0 to 5 years and 6 to 16 years) that "... even in very young children the physiological range of voice parallels that of the lowest reachable physiological tone ....". Their data indicate that even young children have a fundamental frequency range of two-and-one-half to three octaves. If a conclusion is forced from these rather limited data, it would be that the range of vocal frequency, does not change appreciably during maturation (Kent, 1976).

As far as the variability of the fundamental frequency is concerned, the most extensive study is that of Eguchi and Hirsh (1969), who collected data for 84 subjects representing adult hood and the age levels of 3-13 years, at one year intervals, for vowels /i/, /ae/ , /u/, /e/, /a/, and /O/, as produced in the sentence contexts. The variability of fundamental frequency progressively decreases with age until a minimum was reached at about 10 -12 years. This is taken as the index of accuracy of the laryngeal adjustments during vowel production, then the accuracy of control improves continuously over a period of at least 7 to 9 years.

The discovery that the fundamental frequency variability diminishes with age has important implications for the quantitative investigation of speech development. It is not known at what age, this operant refinement of control begins to appear (Kent, 1976). Sheppard and Lane (1968) in a study of two infants during the first 141 days of life, reported a rather small and constant variability in fundamental frequency values. However, Prescott (1975) discovered small developmental increases in the fundamental frequency variability within th e first nine months of life. Possibly, at the same time that a child gains control over the accuracy of his laryngeal adjustments, he begins to vary fundamental frequency to achieve intonation like effects. Of course to some degree, accuracy of adjustment is requisite for controlled variation. Concerning this subject, studies of infants intonation have revealed evidence that definite pattern are established during first year of life (Kent, 1976).

Hudson and Holbrook (1981) studied the fundamental vocal frequency range in reading, in a group of young black adults, age ranging from 18 to 29 years. Their results indicated a mean range from 81.95 to 158.50 Hz in males and from 139.05 to 266.10Hz in females. Compared to similar white population studied by Fitch and Holbrook (1970), the black population had greater mean frequency ranges. Fitch's white subjects showed a greater range below the mean mode than above. This behaviour was reversed for the black subjects. Hudson (1981) pointed out that such patterns of vocal behaviour may be important clues Which alert the listenen to the speakers racial identify.

McGlone and Hollien (1963) studying the vocal pitch characteristics of aged women, 65 to 79 years, reported that women's speaking pitch variability changes little with advancing age. However, Stoicheff (1981) reported an increase in variability of fundamental frequency in post menopausal adult females, which was interpreted as indicating decreased laryngeal control over fundamental frequency adjustments.

General conclusions about the diagnostic value of fundamental frequency variability are difficult to make because such measurements are helpful in certain pathological conditions but not in others (Kent, 1976).

Shipp and Hontington (1965) indicated that laryngitic voices had significantly smaller ranges than did post laryngitic voices. The results of a study by Murry (1978) showed a reduced semitone range of speaking fundamental frequency in patients with vocal fold paralysis, as compared with normals. After a study, Murry Doherty (1980) reported that the variability in speaking fundament frequency, along the directional and magnitudinal perturbation factors enhanced the ability to discriminate between talker with no laryngeal pathology and talkers with the cancer of larynx.

A number of studies have reported pitch variability in the speech of stutterers. Travis (1927) and Bryngelson (1932) found that stutterers exhibited less pitch variability than did non-stutterers, particularly during highly emotional conditions. Adams (1965) indicated that stutterers show a limited pitch range with an utterance when compared with "good" and "trained" speaker; but not when compared with poor speakers. With spectrographic data schilling and Goeler (1961) and Luhsinger and DuBois (1963) showed that stutterers had less amount of pitch variation in their speech than did normal fluent speakers. Healey (1982) examined certain parameters of speaking fundamental frequency associated wi stutterers and non-stutterers fluent production of a declarative and an interragative utterance, and reported that man stutterers produced a significantly greater range of frequencies than did the stutterers across both the utterances. Lechner(1982)found that the stutterers pitch variability increased more under DAP than in normal auditory feedback mode. However, when stutterers spoke in the presence of masking noise, there were only a few changes in their speaking fundamental frequency patterns as compared with auditory feedback mode. Ramig and Adams (1981) discovered that the stutterers and nonstutterers used a greater range of fundamental frequencies while reading at a higher than normal pitch as when compared with reading in their habitual pitch. More over, reading in a lower-than-normal pitch produced less fundamental frequency variability than reading at habitual pitch levels.

Study by Rashmi (1985), in children, has indicated reduction in fundamental frequency range both in males and females as a function of increasing age and no significant difference between males and females. Thus the review indicates that it is important to have extensive data on pitch variation, as a fundtic of age, before it can be applied to the clinical population. Therefore it is intended to study the pitch variation or range in different age groups of Indian population.

Intensity range in speech: Loudness is in general, the psychological correlate of intensity; the term refers to the "strength of the sensation received through the ear". According to Murphy (1964) "It is an aspect of sensation and is measurable through the discriminatory responses of the listener to the strength of the tones. Although it is basically the psychological correlate of intensity, it varies as a function of frequencies".

The differences in constructing and validating a reliable scale for loudness have been discussed by Gamer, who concluded that "whatever the ultimate solution to the loudness scaling probl may be it is clear that the problem is not a simple one".

"There are unfortunately no psychological data relating to the loudness of speech sounds to their intensity except for some general observations published by Flecher (1929), who found that sounds with a large number of frequency components increase more rapidly in loudness with a raise in intensity than do sounds with fewer components, or the sounds with most of their energy in low frequency region also increase more rapidly in loudness than those with most energy in the high frequencies (Fry, 1970).

From the experiments using pure tones as stimuli, it is clear that the loudness of any complex sound will be dependent upon its frequency components or spectrum.

"The loudness of a sound also depends upon it duration at least within certain ranges. It has been found that for values upto about 0.5 sec. increasing duration produces an increase in loudness for sounds of the same intensity (Bekesy, 1933, Lifshitz, 1936)". "These were results obtained with pure tones and it is almost certain that the effect in the case of complex sounds would be less pronounced, but even some influences of duration as loudness is to be expected in speech, particularly. For short lives sounds such as the fricative portions of plosives and affricatives and unstressed vowels" (Fry, 1970). variation in loudness results from three factors, viz. (l) the force of the subglottic breath (2) elasticity of vocal cords; and (3) the resonance effect of the vocal tract.

Surprisingly little attension has been devoted to the mechanism responsible for changes in vocal intensities. Intensity changes are important in every day verbal behaviour, and it ought to come as no surprise to learn that the extremes in intensity of vocal tones occupy a considerable range, even during conversational speech.

The study of phonology also includes intensity change in energy. Increasing or decreasing total speech power, as discussed by Mol and Uhlenbach (1956), is one of the means of achieving dominance of syllables, words or phrases. Changes in energy signify degree of emotional involvement such as shouting when angry. Use of intensity changes also reveal the speakers perception of physical and psychological distance.

Danste (1970), Komijama (1972), and Coleman et al (1977) proposed a graphic representation of the fundamental frequency intensity profile. The graph was named as "phonetogram" by Dabste and "Phonogram" by Komiyama. Rauhut, et al (1979) proposed the term voice area for the representation of maximal or minimal intensity of voice as a function of pitch.

According to Coleman et al (1977), the average intensity range of phonation (in SPL re: 0.0002 dynes/cm^2) at a single fundamental frequency is 34.8 dB for male and 51 dB for female subjects.

Coleman and Mott (1978) found lower SPL ranges for female children (10 to 13 years) than those of adult females. Further, they observed that the musical range, in terms of fundamental frequency and SPL is more restricted, that is, it lies within the boundaries of physiological range, The mean physiological SPL range was found to be 159 dB, while the mean musical SPL range was 58dB.

Empirically, it is wellknown that the disorders of vocal intensity constitute one of the important components of voice disorder. However, measurement of vocal intensity, as a clinical diagnostic tool has not proved as popular as that of fundamental frequency in voice clinics.

However, Watanebe et al (1977) reported of two patients with laryngeal polyps and laryngeal cancer, who showed no abnormalities in the routine study, but showed an abnormality only in the study of vocal intensity. They, therefore, stressed the importance of vocal intensity as a parameter in showing vocal dysfunction.

Darley et al (1969) in a report on speech characteristics of dysarthric patients, reported equal and excess stress and monoloudness as one of the characteristics. In a spectrographic analysis of ataxic dysarthria. Nataraja and Indira (1982) observed equal stress in the pathologic subject, while variations in terms of intensity on each syllable were seen in the speech of the normal subject.

Little information is available regarding the developmental changes in the range of intensity. However, on similar lines as fundamental frequency variability, it may be hypothesized that the variability in intensity decrease with age. Thus it will be interesting and useful to investigate the intensity variation leading to determination of range in speech of adults of different age groups in an Indian population. It is intended to use this data to compare with the results of clinical population for the purpose of differential diagnosis of various disorders in adult.

Rising and Falling Time of Speech:

Imaizumi et al (1980) while investigating the possibilit sound spectrography for multldimentional analysis of patholog voices, measured the rising time and falling time of sustaine vowels as two pf the parameters, among the nine acoustic para studied. These parameters were measured on amplitude display, rising time was defined as time required for the increase of c all amplitude from a value of 10% of the steady level to 90%. falling time was defined as the time span required for decreas from 90% to 10% of steady level.

Howell and Rosen (1983) measured the risetimes of voicele affricates and fricatives, when the test material occured in sentences, in isolated words and in isolated nonsense syllables The risetimes of affricates were significantly shorter than the of fricatives. Rise times varied with the type of test materia and for all types material were significantly longer than those reported by Gerstman (1957). They also reported that, because rise time varies with the type of test material, no auditory se tivlty at a single rise time value can be responsible for the perceptual distinction between voiceless affricates and fricate

Many pathological conditions are more apparent during the transitional phase of phonation, including the onset and the tea nation of phonation and hence of speech. In this connection, further extensive clinical and basic research is required (Hirano 1981). Further studies have reported that the initiation and termination of voice in stutterers are delayed (Miller, 1977, Base, 1979).

Recent study in acoustic analysis of speech in children showed that there is gradual decrease in rise time of phonatic of all vowels with increase in age in both males and females. A slight increase in the rise time is seem in the 9 to 10 year old group of males and 10 to 11 years old group females (Rashmi, 1985).

Inspite of the fact that these measurements are very simp and important, it is surprising to note that there are no atte to note changes in these parameters with age and different pat logical conditions. It was therefore decided to investigate t aspects in the present study in different age groups of the Indian population.

<u>Harmonics:</u>- The speech spectrum is concerned with the frequen and intensity of each overtone (hormonic) of speech wave. Eve 19th century speech scientists were aware of the important cor butions these overtones make to intelligibility. Over the yes therefore, many investigations of the speech spectrum have bee made. Results from average speech spectrum analysis reveal th "speech energy is generated roughly from 50 to 10,000Hz. This energy is greatest in the 100 to 600Hz region, which includes the fundamental component of speech wave and the first formant (Denes and Pinson, 1963).

Most sound sources, unlike the tuning fork, produce vibra tions which are complex. Rather than vibrating in a simple ho motion, they move in a complex manner which consists of more one frequency. There are two kinds of complex sounds - those which the pattern of vibration, however complex, repeats itsel (periodic) and those in which the vibration is random and has repeatable pattern (aperiodic).

The periodic complex vibration produce signals in which component frequencies are integral multiplies of the lowest f quency of pattern repetition, or fundamental frequency. In pl the fundamental frequency is considered to be the first hormo where as in music the first multiple (2 times the Fo) is call the first hormonic.

In an aperiodic complex wave, the frequencies are not ho cally related as they are in periodic sounds.

The human voice is a low frequency sound compared to most of the sounds of the world, including the other sounds Which humans make above the larynx. Since it contains many hormonic the voice is also a complex sound. The lowest frequency in th voice spectrum (Fo), sets up a hormonic (2Fo), a second hormon (3Fo) and so forth. It is characteristic of the human voice t the higher hormonics have less intensity than the lower hormon so that although the voice contains many high frequency compo-nents, the frequency emphasis on the low frequencies. The int sity falls at 12 dB per octave.

A major difference between the sound of a low frequency a high frequency voice is due to the differences in the spacing hormonics. A child with a fundamental frequency of 350Hz, wou have a second hormonic at 700Hz, a third hormonic at 1050Hz an a fourth at 1400Hz. In contrast, an adult male with fundament frequency at 150Hz, would have a second hormonic at 300Hz, and the ninth hormonic would correspond closely with the child's f hormonic. In the same way, a single person adjusting the freq of his voice also changes the hormonic spacing. The figure sh that the shape and the slope of the spectrum remain similar fo and child. In speech some of these hormonics are emphasized, because of resonant characteristics of vocal tract. The high energy over tones are called formants. These give voice a cer quality which is an important clue in speech perception.

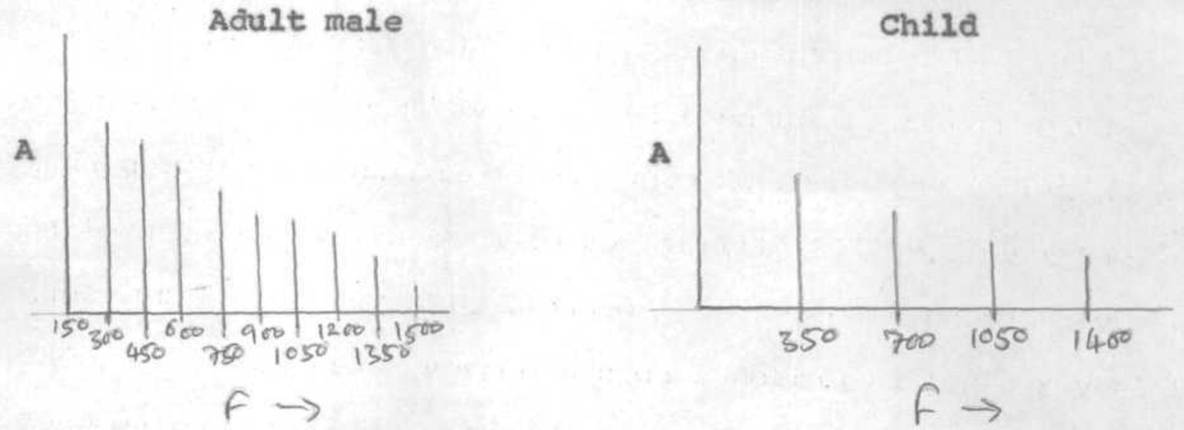


Figure-1: Schematic spectra of sounds resulting from vocal fol vibration. The spectrum represent two different frequencies phonation, thus the hormonlc spacing is altered.

The hormonies produced in phonation or speech have been measured using narrow band spectrograms.

Imaizumi et al (1980) while investigating possibility of utilizing a sound spectrograph for a multidimentional analyst of pathological voices, measured the richness of high frequen hormonics of sustained vowels, as one of the acoustic paramet They adapted a ratio of the mean level of the frequency range between 3.5 and 4.5 KHz to that below 1KHz, using a section d play. Schultz-coulan et al (1979) considered Winckel's sugge (1953) to use the relative amplitude of the 3KHz formant of t vocal spectrum as an objective criterion for vocal efficiency evaluation and studied the dependency of the 3KHz formant an on vocal pitch and intensity in normals by fitter analysis. results showed that the relative amplitude of this formant gr with increase of vocal intensity and decreases with pitch elev tion. This was more pronounced in males than in females. In subsequent study using trained singers, the authors observed that the trained voice have more acoustic energy in the spectr area around 3 KHz than the untrained voices. Among the traine singers also, the male voices differed more than female for th relative amplitude of the 3KHz formant. The amplitude of the lower formant area (800-1300Hz) appeared to be a much better reference quantity than the total intensity level of the voice sample. Their results, therefore, supported Winckel's (1953) theory.

Fronkjaer-Jenson and Prytz (1976) obtained the (alpha) pa meter, defined as the distribution of amplitude above 1000Hz relative to the amplitude below 1KHz in a patient with unilate recurrent laryngeal nerve paralysis, before and after therapy. They found significant reduction in μ (alpha) parameter after th

Yanagihara (1967) has categorized four degrees of hoarsen ranging from slight hoarseness to severe hoarseness, based on spectrographic analysis. In the case of slight hoarseness the regular hormonic components are mixed with the noise component chiefly in the formant region of the vowels. Further, he obse a loss of hormonic components as the severity of hoarseness increased.

Emanuel and Whitehead (1979) found that the level of firs three hormonics of each test vowels (/u/, /i/, /e/, /a/, /ae/

decreased with an increase in roughness, but the higher hormon of /u/ and /i/ showed some reversals. A moderately large negative correlation was shown between lower hormonic level and median vowel rushness.

Dickson (1959) has reported a reduction of the intensity high frequency hormonics, including the region of the third formant, as one of the acoustic characteristics commonly relate to nasality.

Many research workers (Illingworth, 1955; Sedlackova, 1964 Mokoi et al., 1972; Tonkova-Yampolskaya, 1973) have analyzed the hormonic structures in infant cries.

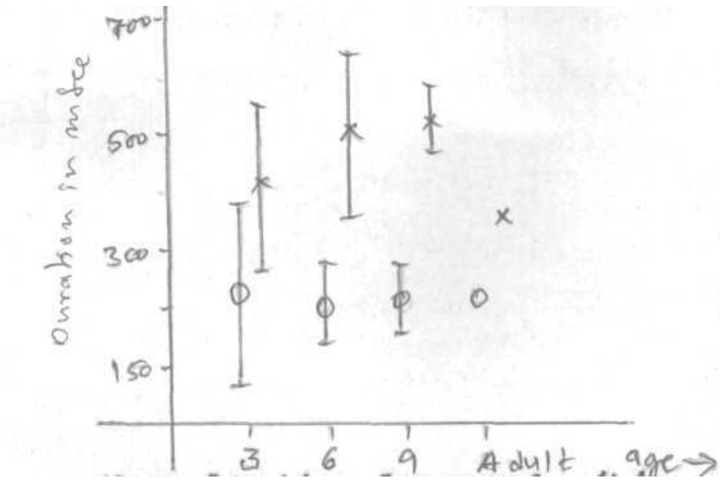
Rashmi (1985) in her study of acoustic analysis of speech in children, reported that the energy level above l000Hz, is le than the energy level below 1KHz. The µ-(alpha) parameter decr between 9 to 14 years in females and 9 to 15 years in male. Th is no significant difference in the µ-(Alpha) parameter between males and females in the age range of 4 years to 15 years.

Hirano (1981) has pointed out that the amount of or riches in spectral hormonics (the mean of a given phonation and the fl tuation in a given phonation) are relevant parameters in the assessment of vocal function.

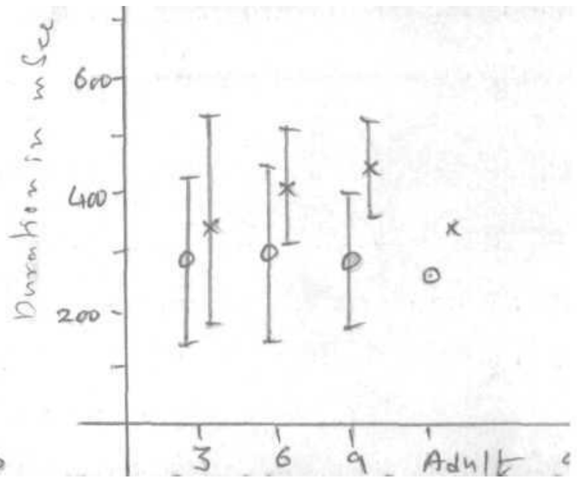
Review of literature thus indicates the possibilities of using the measurement of intensities at various hormonics for t purpose of judging the quality of voice and also in the diagnosis of voice disorders. Further it may be also useful in assessing effectiveness of voice therapy in specific cases of voice disorde Therefore, it was considered that it would be interesting and useful to study this aspect of voice in different age groups of the Indian population. Hence the present study includes measurement of intensity levels at various hormonics.

<u>Vowel duration:</u> Temporal aspects of speech production have received scant attention in developmental studies. This negle is unfortunate because timing may be most critical factor in skilled motor performance. The literature contains very littl about such gross aspects of speech timing as the duration of vowels and contonants (Kent, 1978).

Acoustic studies along this line in children, were recent reported by Disimoni (1974), who made oscilloscopic measuremen of vowel and consonant durations in CVC, VCV, Utterances, of aged 3-, 6-, and 9- years. One conclusion in these studies w that the variability of the duration tended to decrease with a a result which parallels the age - related variances the study Eguchi and Hirch (1969). In addition, the vowel duration in voiceless consonant environments remained relatively consonant all ages tested, while the duration of vowels invoiced conson environments were found to increase with the age



Mean duration ror voweis /i/ & /a/ pooled in voiced(X) and voiceless(o) consonant envl-ronment (data in adult column taken from Peterson & Lehiste, 1960).



Mean duration and standard deviation for vowels in plo (o) & sibilant(X) environmi (Data in adult column take from Peterson and Lehiste, Vowel duration values compared for both voiced and voiceless consonant environments were found to be significantly differen in six - and nine year old subjects, but not in three year old subjects. Durational differences already begin to appear by age three, although the differences do not reach statistical significance until age six. Di Simoni (1974) interpreted his data as evidence of a developmental pattern in which the contr of duration changes rapidly in the period between 3 and 6 year

Smith (1978) reported that the durations of nonsence utte were 15% longer for 4 year olds than for adults and 31% longer for 2 year olds than for adults.

Because few data have been reported on the durations of segments in children's connected, meaningful speech, it is not clear at this time if the lengthening of segment is a uniform property of children's speech. This issue is of interest for atleast two reasons. First, reduction of segment duration wit age may be a consequence of neiromuscular maturation: therefor durational measurements may be one way of characterizing a chi developmental progress in attaining adult like speech motor co A second reason is that developmental patterns in control of d tion are necessary for research on phonological process (Kent,

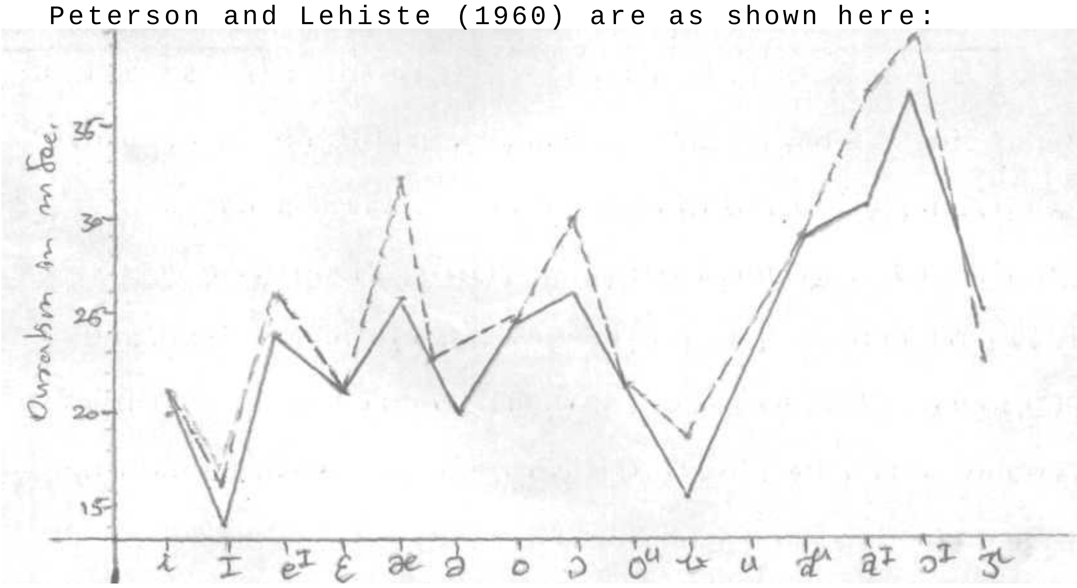
Another developmental pattern emerging from studies of children's speech is an age dependent decline in variability performance (Egnchi and Hirsh, 1969; DiSimoni, 1974). If vari bility is taken as an index of maturation of motor control, th it appears that a child's speech production continues to impro in precision until atleast 11 to 12 years of age. This gradual decline in performance variability as a function of age, accor with part of Bruner (1973) definition of skilled act of develop

Recent speculation on the role of the cerebellum in motor control often emphasizes the need for the cerebellum to gain e rience in motor accomplishment and to learn" from that experi to predict and modify as required the motor consequences of ef rent out flow. By this reasoning the cerebellum must be an act participant in the motor learning of speech production too. is atleast a superficial resemblance in so far as both normal: individual with dysarthria of cerebellar origin tend to have segments that are longer and more variable in duration, than of normal adults (Kent, Netshell and Abbs, 1979). In this wa systematic studies of temporal regulation in developing and ordered speech should be helpful in testing hypotheses about structure of motor programs in speech productions and the way which these programs are acquired or maintained.

Variability of timing control is important in characteri both developing and disordered motor control, whether for spe or motor behaviour. When variability of timing is used to de developing or disordered speech, it is important to recognize possibility that increased variability may be related simply rate and not necessarily to neuromuscular immaturity or neuro-logic damage. Same reports showing heightened variability for young children or persons with speech disorders may really be evidence of general rule that show speakers are more variable intiming control than fast speakers.

Vowel duration has been measured in various languages - English (Klatt, 1980, Raphel, et al 1975; Walsh and Parker, 1981); Kannada (Rajpurohit, 1982); Malayalam (Velayudhan); Tamil (Balasubramanyan, 1981); Japanese (Homma) 1981); French (O'Shaug 1981) Mack, 1982); Swedish (Lyberg, 1981), Hungarian (Fonagy, Fonagy and Duphy, 1980) and in Dutch (Nootboom, 1972).

The average duration of English vowels from a study by Peterson and Lehiste (1960) are as shown here:



Average duration of syllable nuclei, measured from minimal pairs differing in the voicing of the final consonant. The solid curve is for a large set of CVC words spolem by one speaker, whi dotted curve represents value of 30 minimal pairs uttered by 5 speakers (Peterson and Lehiste, 1960).

Duration of individual segments differ widely from these averages due to systematic influence of phonetic and syntactic environments. There are a host of variables Which affect the duration summarized in table given below.

Factors that influence the durational structure of a sentence (Klatt, 1976)

Extralinguistic:

Psychological and physical state (Williams and Stevens, 1972)

Speaking rate (Huggeins, 1964, Goldman-Eisler, 1968).

Discourse level:

Position within a paragraph (Lehiste, 1975).

Semantic:

Emphasis and semantic novelty (Coker et al 1973)

Syntactic:

Phrase structure lengthening (Martin, 1970; Klatt, 1975)

Word level:

Word final lengthening (Lehiste, Oiler, 1973).

Phonological/phonetic:

Inherent phonological duration for a segment (Peterson and Lehiste, 1960).

Effect of linguistic stress (Parmanter and Trevino, 1936)

Effect of post vocalic consonant (Hoose and Fairbanks, 1953).

Segmental interactions, for example, consonant clusters (Klatt, 1973; Haggard, 1973)

Physiological:

In compressibility (Klatt, 1973).

In addition to these factors, Lyberg (1981), reported a strong relationship between duration and the fundamental frequ change. However, he further goes on to say that the fundament frequency contour can never be a secondary effect of the segme ddrations and that it seems quite impossible to generate the fundamental frequency contour from duration values.

Lee (1978) has reported that the difference in duration between tone classes is primary by the shape of the fundamental frequency contour. The intrinsic duration of a vowel in a tone language is conditioned by the tone that the vowel carries.

On other hand, Nooteboom (1972), Cooper (1976), Llndblom et al (1976) and Lehiste (1976) have observed the duration to b independent of the fundamental frequency contour. Nataraja and Jagadeesh (1984) have shown relationship between fundamental frequency of voice and vowel duration. They found that any char in fundamental frequency leads to increase in vowel duration.

Rashmi(1985)has studied vowel duration in childrened. She has reported that decrease in vowel duration as a function of age in both males and females, and females have a longer vowel duration when compared to the males.

Measurements of vowel duration have been made using. Oscillograms, spectrograms, electrohymographi tracings and computors.

A review of literature indicates that although vowel duration differences are very reliably produced, their role in perce tion is not as predictable. The duration of the preceding vowel is often cited as an important cue to voicing feature of final stop consonants in English; preceding vowel duration has been called under certain conditions as primary (Klatt, 1976) and even necessary (Ramphael, 1972) cue to voicing distinction. However Ward rip-Fron (1982) has suggested that in neutral speech vowel duration differences are probably neither necessary nor adequate cues to this distinction and that voicing during closu may be required to disambiguate voiced stops.

For American English, the finding of shorter vowel duratio before voiceless as opposed to voiced stop is consistent over a large number of adult speakers, studies and phonetic environmen (House, 1961; House and Fairbanks, 1953; Klatt, 1973). For pre pausal syllables, the vowel before the voiceless cognate avera about 60% of vowel before the voiced cognate.

It appears that a refinement of vowel duration with an increase in age is demonstrated for both speech perception and production (Krause, 1982) perceptual research an infant subjec in Wiich vowel duration cued the voicing contrast has revealed noncategorical like discrimination for post vocalic consonant voicing (Eilers, 1977; Eilers et al, 1977). This may indicate that a voicing contrast that depend on the vowel duration cue more "difficult" to learn than other acoustic cues for post vocalic voicing contrasts (Krause, 1982).

Studies applied to normal and clinical populations will define process for normal perception production development and may have potential for direct diagnostic and therapeutic applic tion with speech and language impaired individuals.

Vowel duration has been studied in some speech impaired adults. DiSimoni (1974) in a preliminary study of a certain timing relationship in the speech of stutterers indicated that differences exist in the duration and in certain aspects of timing of fluent sequences of phonemes in stutterers. Stutterer also showed greater variability than non-stutterers in duration control.

Christensen and Weinberg (1976) observed that the overall vowel durations of esophageal speakers were consistently longer than those of normal speakers, indicating that esophageal speaker do not compensate for their striking dimunition in air supply for speech by decreasing the vowel duration.

Collins, Rosenbeck and Wertz (1983) pointed out that most normal speakers of English reduce the duration of the vowel, as the words increase in length. However, in a spectrographic analysis of vowel duration in apraxia of speech, they found the vowel duration to be significantly longer than those of normal speakers. The results suggest that the vowel reduction is a robust phenomena which resists impairment in apraxia of speech, despite often significant disturbances in motor programming.

Review of literature on vowel duration indicates that slight use has been made of the temporal properties of speech production in the evaluation of developmental abnormalities. Investigation of adult speech have revealed that the timing of speech movements is under fine control such that successive movement in the produc tion of a phonetic sequence may be separated by as little as 10ms (Kent, 1976).

It is likely that timing variable could provide a sensitive metrics for the evaluation of the neuromuscular maturation of the speech mechanism. As Tingley and Allen (1975) noted, studies of timing in various motor tasks have revealed a progressive refi ment of control "from earliest tested, through puberty". Thus motortimingforspeechandnon-speechactivitiesmaydevelopalo a continuum that span atleast 12 years of life.

Analysis of duration of vowels has been considered only with reference to semantics. However, in recent study Nataraja and

Jagadeesh (1984) have shown relationship between fundamental frequency of voice and vowel duration. No reports are availa to show whether there is only relationship between vowel duration and age. But from the above mentioned study it can be hypothesized that the vowel duration would vary with age. Hen it was considered that it is necessary to obtain this information both theoretical and clinical point of view and it was decided to determine the vowel duration in speech in different age groups of Indian population using Kannada language.

Primary value of this study lies in presentation of normative data which reflects the physiological changes with age and against Which the potentially pathological voice and or speech can be measured. Before a variable can be used to assess a pathologic condition, it is necessary to understand the variabl in relation to the normal voice/speech and its productive capabilities. Acoustic analysis may provide a significant non-invas tool for the detection of laryngeal diseases. But before it can be used successfully, larger normal populations and population with a varieties of disorders must be studied.

CHAPTER III

METHODOLOGY

The study waS aimed at iavestigating the changes in following parameters as a function ofage in adults;

1. Speaking fundamental frequency
2. Frequency range in speech
3. Intensity range in Speech
4. Rise time of speech
5. Fall time of speech
6. Harmonics
7. Vowel duration

Subjects:- Adults both males and females age ranging from 16 to 65 years were randomly selected for the study The in criteria for the selection of the subjects is the absence of any speech and/or hearing, and/or respiratory problems with no observable deformities of the nasal, oral or pharyngeal cavities

one hundred adults were selected, such that, ten males and ten females were included in each of five groups with 10 years Interval.

Age range in yrs	Males	Females
16-25	10	10
26-35	10	10
36-45	10	10
36-55	10	10
56-65	10	10

Table 3.1 : Distribution of subjects in each age group.

Test Material:- Three kannada sentences were selected for the analysis of their speech.

1. idu pa: pu
   (ಇದು ಪಾಪು This is baby)

2. idu ko:ti
   (ಇದು ಕೋತಿ This is monkey)

3. idu kempu banna
   (ಇದು ಕೆಂಪು ಬಣ್ಣ This is red colour)

These three sentences were chosen, as they have been used in earlier studies of acoustic analysis of speech in children (Kushal raj, 1983; Rashmi 1985). Further it consists of three vowels and two consonants required for analysis.

Data collection:

The data was collected in the following manner:

Speech samples of subjects were recorded. The subjects were instructed as follows:

"Now I will say three sentences. Repeat each sentence three times". The sentences "idu pa: pa", "idu ko: ti", and "idu kempu banna", were spoken by the investigator and the repitition of these sentences by the subject was recorded.

The recording were made using a philips tape recorder with built in microphone and coney cassettes.

Recording Room: The responses were recorded in a quiet, isolated room, where noise is minimum and doesnot interfere with the recording.

Analysis

1. Measurement of mean speaking fundamental frequency: The following instruments were used for the measurement of mean speaking fundamental frequency.

1. Tape recorder (Philips F 6112 stereo casette deck)
2. Pitch analyzer PM 100
3. Speaker (Sois 2211, Ampli speaker)

Photo: 1. PITCH ANALYZER (P.M-100)

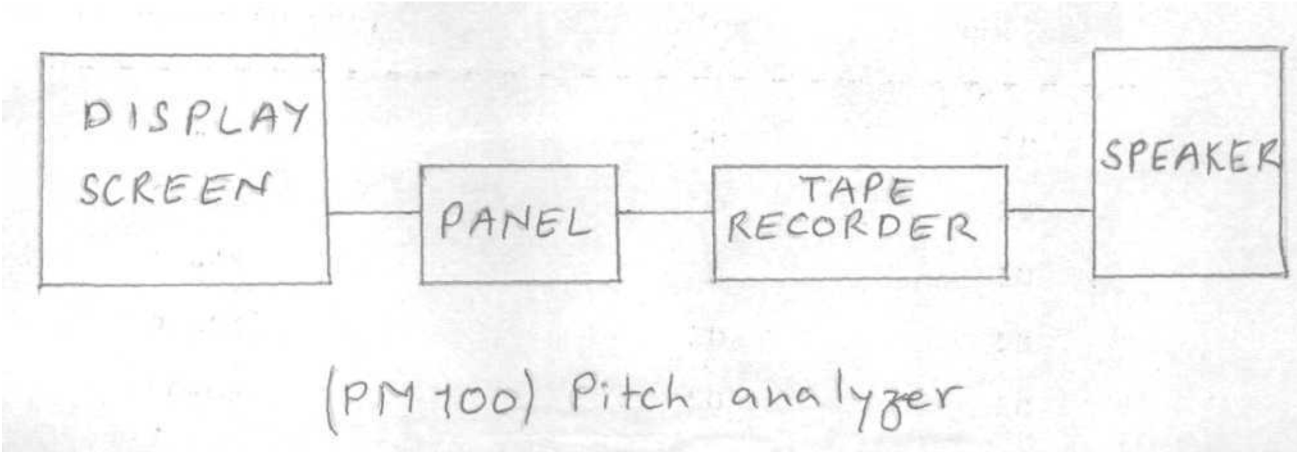


Fig. 3.1: Experimental set up used for the measurement of speaking fundamental frequency.

Signal was fed from tape recorder to pitch analyzer PM 100 through line jack. Output from tape recorder was also fed to the speaker which provided an auditory feed beek of signal being fed, to the investigator. The instruments were calibrated before and while carrying out analysis. The display duration was set to the one second so that each stimulus sentence could be displayed more clearly and enlarged. The stimulus sentences "idu pa: pu", "idu ko : ti" and "idu kempu baana" were fed to the pitch analyzer. The mean speaking fundamental frequency for each sentence was directly read on the digital display at the and of the screen. The mean frequency used for speaking by each subject was obtained.

2. Measurement of the frequency range in speech

With the same experimrntal set up and stimulus sentence fed to the pitch analyzer as in analysis 1. The frequency range used by each subject in speech was determined by moving the cursor to the highest and lowest frequency in the test sentence, and finding difference between two. This was found fo each of the test sentence, namely "Idu pa: pa", *idu ko: ti" and "Idu kempu banna". This provided the frequency range used by each subject in speaking.

3. Measurement of intensity range in speech

These measurements were made similar to the measurements of frequency range in speech as in analysis 2. With each test sentence fed to the pitch analyzer, the cursor was moved to the highest and the lowest intensity occuring in the sentence. The difference between these two, provided the intensity range in dB, usedin each of the sentence, for each subject.

4. Measurement of the Rise time and the Fall time of speech

The sample selected for analysis 1, was used for the measurement of rise and fall time of speech also with the experimental set up and stimulus sentence fed to pitch analyzer as in analysis 1. The rise time in centiseconds was measured by moving the cursor from the point where the intensity curve begins to the point where the curve becomes steady. The difference between these two points provided the rise time in centiseconds.

Similarly, the fall time was measured by moving the cursor from the end of the steady portion of the intensity curve to the last point where the curve is visible. The difference between these two points on the time scale, was noted down as the fall time in centiseconds.

This waa done for all the three sentences.

5. Measurement of vowel duration

The following instruments were used for the measurement of the vowel duration:

1. High Resolution signal analyzer (B&K 2033)
2. Tape recorder (Philips F6 112 stereo cassette deck)
3. Speaker (Sois 2211, Amplispeaker)

Fig. 3.2 Experimental set Up for the measurement of vowel duration.

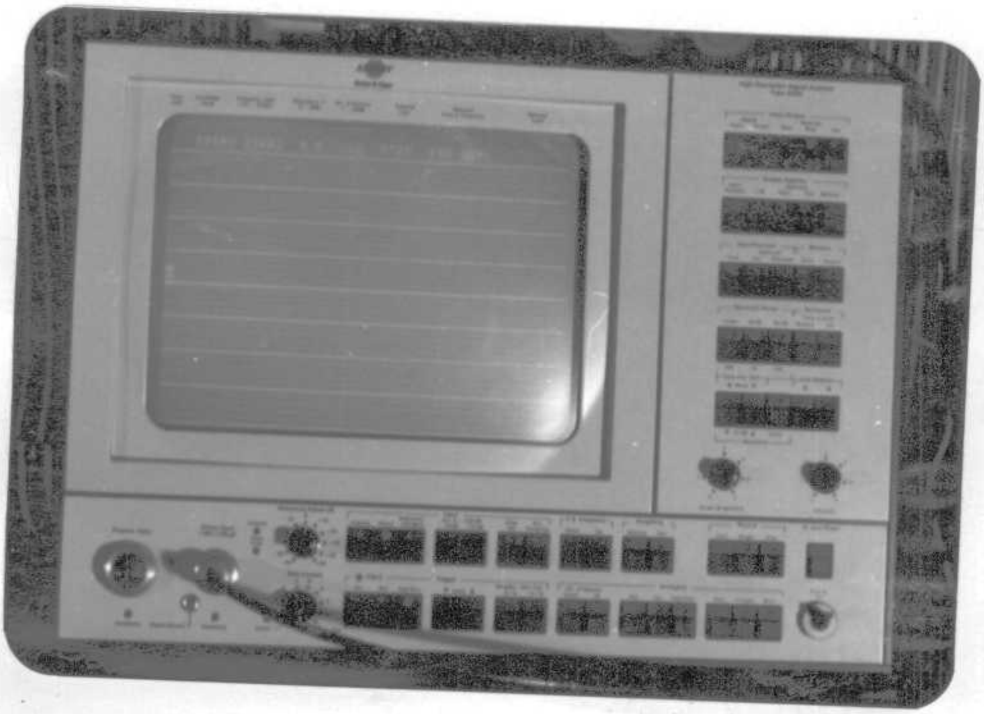


Photo: 2. High resolution signal analyzer
(B&K: 2203)

The signal was fed from the out put of the tape recorder to the high resolution signal analyzer through the line in jack. The out put from the tape recorder was also fed to the speaker which provided an auditory feed back of the signal being fed, to the investigator. Instruments were calibrated before and while carrying out analysis.

With this experimental set up, the word "idu" from one of the stimulus sentences, which was considered as "Good" by the experimenter, was fed to the high resolution signal analyzer (B & K 2033) in the time mode, with the following setting.

Input : "Direct" - connects the direct in put to the input amplifier*

Full Scale Level: 2.82 volts, this indicates the full scale level display on the HBSA display screen in volts peak, assuming that the input gain, etc. are adjusted, such that the HRSA's internal reference reads 100 dB or 100 mV.

Frequency: 200 Hz

Input function: "Time" - causes the display selector to the time function.

The signal was fed to the HRSA. As soon as the word "idu" appeared on the display screen, the "stop" key was applied. The cursor was moved to the point where the vertical striations began, that is, to the beginning of the envelope and then to the end of the envelope. The difference in milliseconds between two points was recorded as the duration of the vowel /i/ in "idu". Thus, the duration of the vowel /i/ in "idu" as uttered by each subject was obtained.

With the above experimental set up end the same stimulus word fed into the HRSA as in analysis 5, the cursor was moved to the middle of the envelope of the vowel /i/ of "idu", and the input function, showing "Inst. Spectrum" was switched on. This caused the input function to the display selector to be the instantaneous specturm. The frequency scale selected was 2000 Hz.

Peaks were amen on the display screen at different frequency levels. The cursor was then moved to the peak in each envelope. 1 first peak corresponded to the fundamental frequency and the following peaks to the harmonies. The intensity (harmonic) was read directly on the digital display. This value was added to the reference intensity level of 20dB, This provided the intensity of the harmonics up to 2000 Hz.

Reliability:

To find out realibillty 15 samples, which are randomnly selected were reanalysed for all the parameters. No significant difference were found on any of the parameters.

Thus the following parameters were obtained for all one hundred subject.

-Speaking fundamental frequency

-Frequency range in speech

-Intensity range in speech

-Rise time and fall time of speech

-Harmonics

-Vowel duration

The obtained values were then tabulated and subjected to statistical analysis.

CHAPTER -IV

RESULTS AND DISCUSSION

The study was aimed at examining the variation in the below listed parameters, as a function of age and sex in adults ranging in age from 16 to 65 years.

1. Speaking fundamental frequency
2. Frequency range in speech
3. Intensity range in speech
4. Rise time of speech
5. Fall time of speech
6. Vowel durations, and
7. Harmonics.

The mean and standard deviation of all the parameters in each age group have been calculated, for both males and females. The significance of difference between the age groups and between males and females have also been determined using t-test.

Speaking fundamental frequency:

The speaking fundamental frequency for all the 3 test sentences were found by the method described in chapter-III. The mean and standard deviation for both males and females are presented in table-4.1 and graph 4.1.

Males: The inspection of the table 4.1 and graph 4.1 showed that for the stimulus sentences speaking fundamental frequency increased gradually with age in males. Table 4.1 and graph 4.1 also shows that the age group 16-25 years had the lowest speaking fundamental frequency (mean S.F.F. of 139.7Hz) and, the age group 56-65 years showed the highest speaking fundamental frequency (Mean S.F.F. of 149.76Hz) for males.

By inspection of table 4.2 it was cleat that, there was no significant increase in S.F.F. When two consecutive age groups are compared. For example, there is no significant difference in speaking fundamental frequency when the age group 16-25 years and the age group 26-35 years were compared where as when the age group 16-25 years and the age group 36-45 years were compared there was a significant increase in S.F.F.

The mean S.F.F. has changed from 139.7Hz at the age group 16-25 to 149.76 Hz in 56-65 age group.

These findings are similar to the findings of Bohme and Hecker (1970). They found that in advanced age, the mean S.F.F.

becomes higher in men. Holllen and Shipp (1972) also reported that from 60 years to 80 years S.F.F. increases in male.

Research has shown that changes in level and pitch range accompany growth and the age process. The results obtained by Fairbanks (1942), Fairbanks Wiley and Lassman (1949), Maysak (1959) suggest vocal pitch lowers at the rate roughly corresponding to laryngeal growth and, at middle age the pitch level begins to rise slightly with increase in age ossification and calcification of laryngeal cartilages begin to take place. At the age of 65 years entire laryngeal frame except arytenoid cartilage will be ossified.

Hence the hypothesis stating that there is no significant difference in S.F.F. as a function of age in males was partly rejected and partly accepted.

Females: The examination of the table 4.1, shows that, in females the S.F.F. increased with the age upto the age of 55 years. From the age 55 year onwards the S.F.F. decreased significantly. Table.4.1 also showed that the highest S.F.F. is shown by the age group 56-65 years (mean, S.F.F. of 258.3Hz) and the lowest S.F.F. is shown by the age group 16.25 years (mean S.F.F. of 224.5 Hz).

Inspection of table.4.1 also showed that the age groups 36-45 years (S.D.24.2) and 56-65 years (3D of 21.9) are more variable groups than other age groups.

		16-25	26-35	36-45	46-55	56-65
Males	Mean	139.7	142.38	147.1	147.6	149.76
	S.D.	7.2	12.66	16.14	16.14	14.22
Females	Mean	224.5	230.04	243. 36	258.3	234.73
	S.D	8.19	14.4	24.2	11.3	21.9

Table-4.1: Speaking Fundamental Frequency.

Mean and Standard Deviation of speaking fundamental frequency (in Hz) in males and females.

	16-25	26-35	36-45	46-55	56-65
16-25			P*	P*	P*
26-35				P*	P*
36-45					P*
46-55					-
56-65					

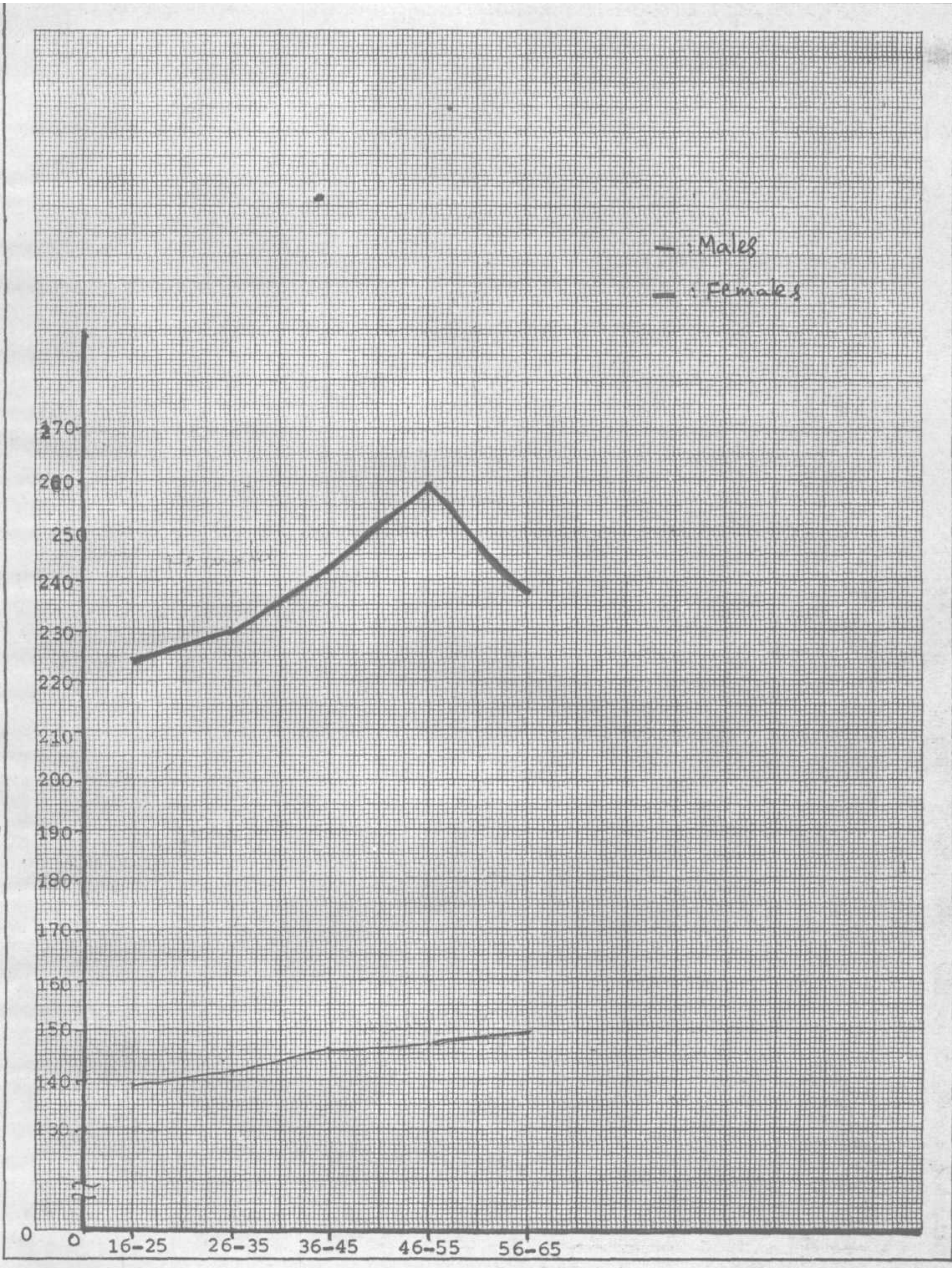
Table-4.2 : The significance of difference between different age group of males on the speaking fundamental frequency.

* - Key is provided in Appendix-II

	16-25	25-35	35-45	46-55	56-65
16-25		--	P*	A*	P*
26-35			--	A*	P
36-45				A*	P
46-55					P
56-65					

Table-4.3: The significance of difference between different age groups of females on speaking fundamental frequency.

* - key is provided in Appendix.II



4.1 Speaking fundamental frequency in males and females

Table 4.3 showed that there is no significant difference between two consecutive age groups, but when compared to next group, there is significant difference between two age groups. This shows the S.F.F. changed gradually with increase in age in case of females.

Similar findings are reported by Bohme and Hecker (1970). Their findings showed that in advanced age the mean speaking fundamental frequency decreased. Kelly (1977) and Stoicheff (1978) also reported similar findings. Hence the hypothesis stating there is no significant difference in S.F.F. as a function of age in females is partly rejected and partly accepted.

Sex difference: The comparison of S.F.F. between males and females is presented in table 4.4. Inspection of table 4.4 showed that there is a significant difference between males and females with respect to S.F.F. Table 4.1 shows that males use lower S.F.F. when compared to females from 16-65 years. There is a maximum difference of 110.7Hz at 46-55 years age group and a minimum difference of 84.8GHz at 16-25 age group between males and females. These results are in line with the well known fact about the difference in fundamental frequency of vibration of vocal cords in case of wales and females. This difference in frequency of vibration are attributed to the differences in the vocal systems in males and females. Hence the hypothesis stating that there is no significant difference between males andfemales with respect to S.F.F. is rejected.

16 - 25	P
26 - 35	P
36 - 45	P
46 - 55	P
56 - 65	A*

Table - 4.4: Significant difference between males and females on speaking fundamental frequency.

* - Key is provided in Appendix-II

The results on speaking fundamental frequency can be summarized as:

1. These is a gradual increase in S.F.F. with increase in age in males. The changes in S.F.F. are more at old ages i.e. above 55 years.

2. There is a gradual increase in S.F.F. with increase in age till 55 years in females. From 56 years, the S.F.F. loweres in case of females.

3. There is significant difference between males and females as far as S.F.F. is concern. Males use lower S.F.F. than females throughout the age range studied.

The S.F.F. has varied from 139.7Hz to 149.76Hz from 16-25 years of age to 58-65 years of age in case of males and females in case of females and 224.5Hz to 234.73Hz from 16-25 years of age to 56-45 years of age. Further on the average a difference of 129.7Hz is seen between males and females, in terms of S.F.F.

Frequency range: The frequency range utilized in 3 test sentences were determined by the method described in Chapter-III. The mean and standard deviation for each age group in both males and females are provided in the table 4.5. Graph-4.2

Males: Examination of table 4.5 and graph 4.2 show that the frequency range in males increases significantly as a function of age upto the age of 45 years. From 46-65 years the frequency range decreases as age increases. The table 4.5 also shows that, the age group 16-25 years has the lowest frequency range (mean frequency range of 134. 7Hz) and the age group 36-45 shows the highest frequency range (mean frequency range of 181.49Hz). Inspection of table 4.5 shows that the age groups 46-55 years (SD of 22.6) and 56-65 years (SD of 24.53) have greater variability than other groups.

The inspection of table 4.6 reveals that there is significant difference in frequency range in males When different age groups are compared. There is gradual increase in the frequency range upto the age of 45 years and from 46-65 years, frequency range decreases as a function of again males.

Fitch and Holdbrook (1970) reported that black population showed greater mean frequency range then White population. Hudson (1981) indicated that the frequency range varies according to race. Kent (1976) found similar findings. He found that as age increases, the frequency range also increases as individual express more intonatlonal and stress information in speech.

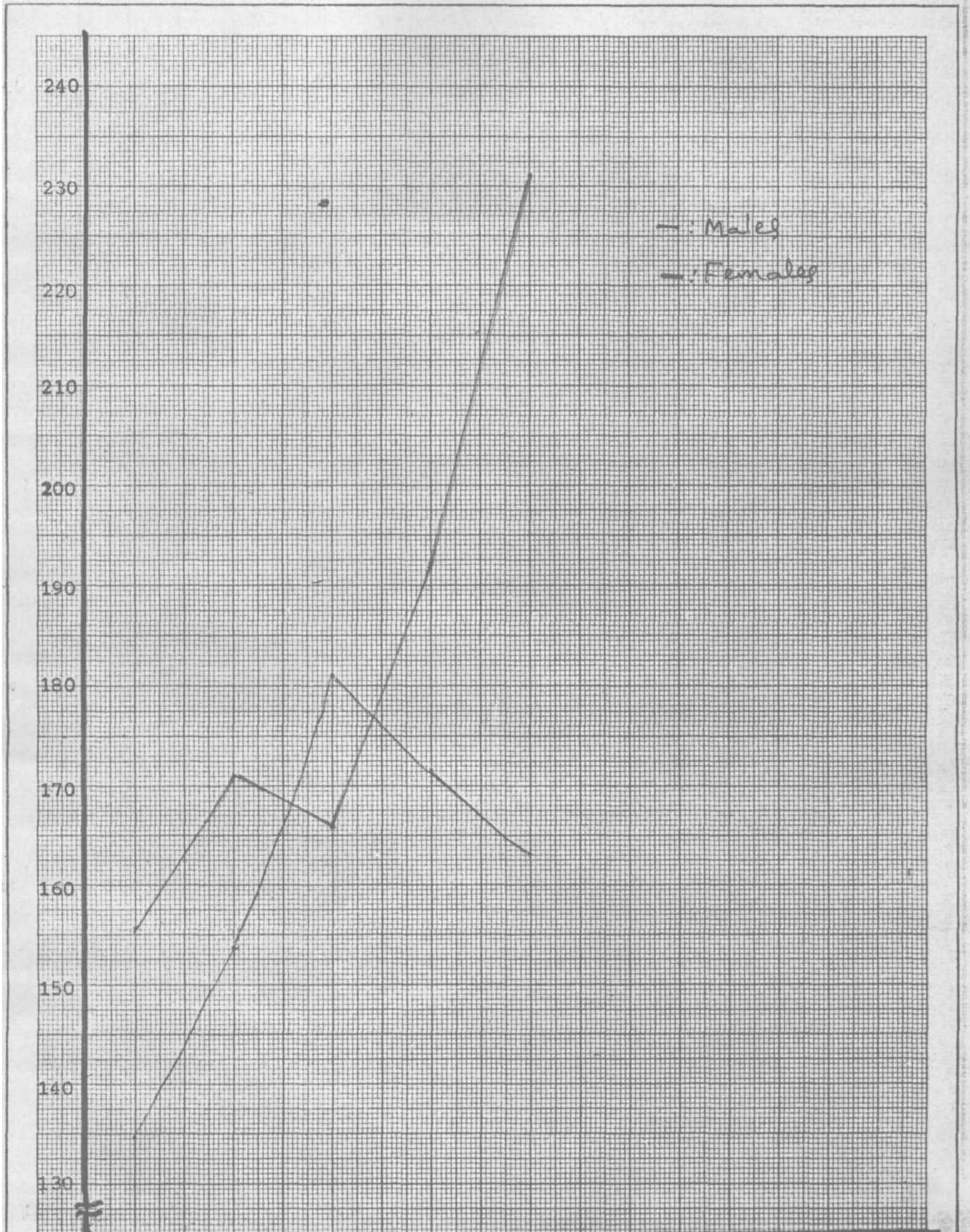
		16-25	26-35	36-45	46-55	56-65
Males	Mean	134.7	153-36	181.49	172.17	163.5
	SD	18.7	19.22	19.15	22.6	24 53
Females	Mean	155.73	171.26	165.86	192.25	232.7
	SD	24.79	27.82	16.04	23 91	25.47

Table 4.5: Mean and standard deviation of fregquecy range(in Hz) in males and females.

	16-25	25-35	36-45	46-55	56-65
16 - 25		P*	P*	P*	P*
26 - 35			P*	P*	P*
36 - 45				A*	A*
46 - 55					A*
56 - 65					

Table-4.6: The significance of difference between different age group of males on the frequency range.

* - Key is provided in Appendix-II



4.2: Frequency range in males and females.

The decrease in frequency range from 46 to 65 years can be attributable to loss of laryngeal control due to aging process.

Hence the hypothesis stating that there is no significant difference in frequency range as a function of age in males is partly rejected and partly accepted.

Females: The inspection of table 4.5 and graph 4.2 indicate the frequency range changes as a function of age in females are inconsistent. Table 4.5 shows that the age groups 16-25 years has the lowest frequency range (mean frequency range of 155.73) and the age group 56-65 years has the highest frequency range (mean frequency range of 231.7Hz). All age groups have shown high variability in their scores (Table 4.5).

Table 4.7 shows that there la significant difference between age groups with respect to the frequency range. But there is no consistent pattern in variation.

Stoicheff (1981) reported an increase in variability of fundamental frequency in post menopausel adult females, which was interpreted as indicating decreasing laryngeal control over fundamental frequency. The present atudy also found similar findings. However McGlone and Hollien (1963) studying pitch characteristics of aged women, from 65 to 79 years reported that the women speaking pitch variability changes little with

	16-25	26-35	36-45	46-55	56-65
16 - 25		A*	P*	P*	P*
26 - 35			P	P*	A*
36 - 45				P*	P*
46 - 55					P*
56 - 65					

Table-4.7: The significance of difference between different age group of females on the frequency range.

advancing age. Hence the hypothesis stating that there is no significant change in frequency range as a function of age in females is partly rejected and partly accepted.

Sex difference:- The examination of Table-4.8 shows that significance difference between males and females with respect of frequency range. Table-4.5 shows that females use a greater/larger frequency range than males in all age groups except the age group 36-45 years, where males have used greater frequency range in speech than females. Table-4.5 also indicates that the female groups are more variable than males.

Hudson and Holbrook (1981)reported similar findings. Their investigation has shown that females use greater frequency range in speech than males.

Hence the hypothesis stating that there is no significant difference between males and females with respect to frequency range in speech is partially accepted and partially rejected.

The findings on the frequency range in speech are summarized below:

1. Males show an increasing trend in the range of the fundamental frequency with the increase in age upto age of 45 years. From

	--
16 - 25	
26 - 35	P
36 - 45	P*
46 - 55	P
56 - 65	P

Table-4.8: significant difference between males and females on frequency range.in speech.

* - Key is provided in Appendix-II

46-65 years males show decreasing trend in the frequency range of speech with increase in age.

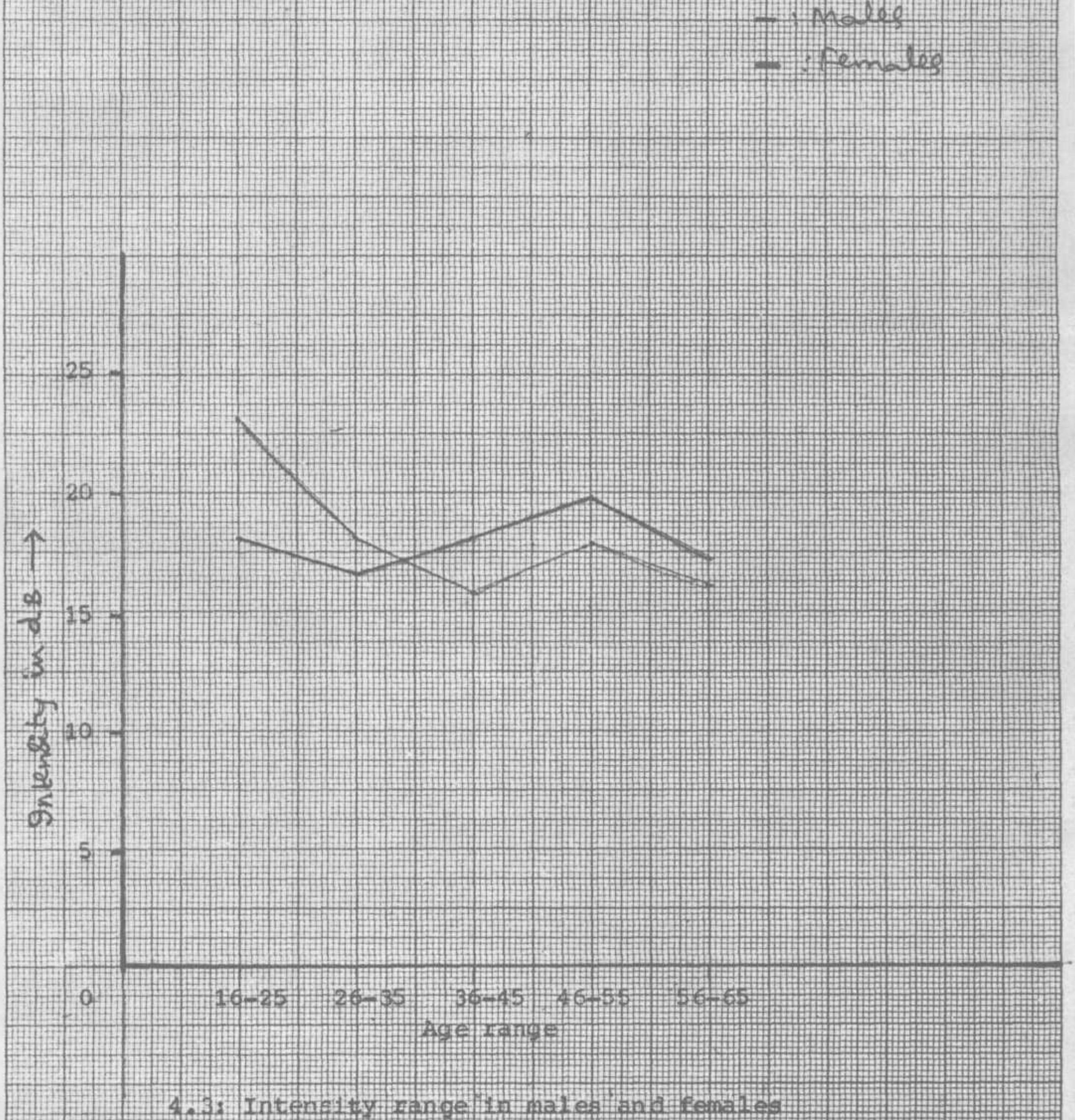
2. Females also exhibited increasing trend in the range of fundamental frequencies used in speech as a function of age.

3. Females use greater range of fundamental frequency in speech than male.

Intensity range in speech: Intensity range was computed for all 3 teat sentences by using the method aa atated in Chapter-II The mean and the atandard deviation for each group and for both malea and females, are preaented in the table 4.9 and graph 4.3

Males: Examination of Table 4.0 and graph 4.3 show that intensity range is speech decrease as a function of age in males. Table-4.9 shows that the age group 16-25 years has the highest intensity range (mean intensity range in speech of 23.18dB) and the age group 56-65 years show lowest intenaity range (mean intensity range in speech of 16.82dB). Results of further statistical analysis given in Table—4.10 shows that there is no significant difference between different age groups, except when the age group 16-25 years ia compared with the age groups 46-55 years. When the age group 16-25 years is compared with the age groups 46-55 years and 56-65 years, there is decrease in intensity range as a function of age and when the age group 26-35 years is compared with the age group 56-65 years, the age group 26-35 years has shown higher intenaity range than the age group 56-65 years. Table 4.9 also points out that the ape group 56-65 years has significantly lower intensity range in speech when compared to all other age groups in males.

Rashmi (1985) has found similar findings with the children. She reports that the intensity range in speech decreases as a function of age in males.



4.3: Intensity range in males and females

Hence the hypothesis stating that there is no significant difference in intensity range in speech as a function of age in males, is partially accepted and partially rejected.

Females: The inspection of table 4.9 and graph 4.3 show inconsistency in females with respect to intensity range. Table 4.9 shows that the age group 46-55 years has the highest intensity range (mean intensity range in speech of 19.14 dB) and the age group 56-65 years has the lowest intensity range (mean intensity range in speech of 17.05 dB).

The inspection of table-4.11 indicates that there is significant difference in intensity range when the age groups 16-25 years and 56-65 years are compared. The age group 16-25 years has higher intensity range (i.e. 18.39 dB) than the age group 56-65 years (i.e.17.05 dB). The examination of table 4.11 also indicates that there is significant difference in intensity range when the age group 25-36 years is compared with the age groups 46-55 years and 56-65 years. The age groups 46-55 years and 56-65 years have higher intensity range than the age group 25-36 years.

The intensity range maximum seen in the 46-55 years age group is 19.14dB and minimum seen in the age group 26-35 is 16.65 dB in case of females.

Hence the hypothesis stating there is no significant difference in intensity range in speech in females is partially accepted and partially rejected.

	16-25	26-35	36-45	46-55	56-65
16-25		-	-		- P*
26-35				A*	A*
36-45				-	-
46-55					-
56-65					-

Table- 4.11: The significance of difference between different age group of females on Intensity range.

* - Key is provided in Appendix-II

Sex difference: The inspection of table 4.12 shows the significant difference between males and females with respect to intensity range in speech. Table.4.12 points out that there is no significant difference among majority of groups with respect to Intensity range, but the age groups 16-25 years, 26-35 years have shown sex difference with respect to intensity range. Males show significantly higher intensity range than females in these age groups.

Maximum of 4.69dB and minimum of 2.05Hz difference in intensity range has been observed between males and females.

Hence the null hypothesis stating that there is no significant difference in the range of intensity in speech is partly accepted and partly rejected.

The study of the range of intensities utilized in speech reveal the following:-

1) There is gradual but in significant decrease in range of intensities in speech in males: The younger age group show higher intensity range than older age group.

2) In females the results are inconsistent. Few groups have shown higher ranges than others.

16 - 25	A
26 - 35	P
36 - 45	A-
46 - 55	-
56 - 65	-

Table- 4.12: Significant difference between males and females on intensity range in speech.

*Key is provided in Appendix-II.

3) Difference in the range of intensities between two sexes is not significant. In few age groups males use higher range than females.

This indicate that intensity range of speech does not very much with the age in males and females.

Rise time of speech: The rise time of speech was found by subtracting the point at which intensity has stated to the point at which, it has become steady on the time scale in centiseconds. The rise time of speech was found for 3 test sentences. The mean values with the standard deviation for each age group, for both males and females is presented in table-4.13 and graph 4.4.

Males: The study of table 4.14 reveals that there is no significant difference among different age groups in terms of rise time in males. However when the age group 16-25 years group is compared with the age group 56-65 years, the older age group shows longer rise time than the younger age group and when the age group 26-35 years is compared with the age group 56-65 years, the older age group has shown longer rise time than younger age group.

The examination of table 4.13 shows that the age group 16-25 has obtained the lowest rise time (mean raise time of 6.3 centiseconds) and the age group 56-65 years has shown highest rise time (mean rise time of 9.74 centiseconds). The table 4.13 also points out that there is gradual, but not significant, increase in rise time as a function of age in males. Longer rise time in the age group 56-65 years, wham compared to other groups may be due to changes in neuro muscular control with aging process.

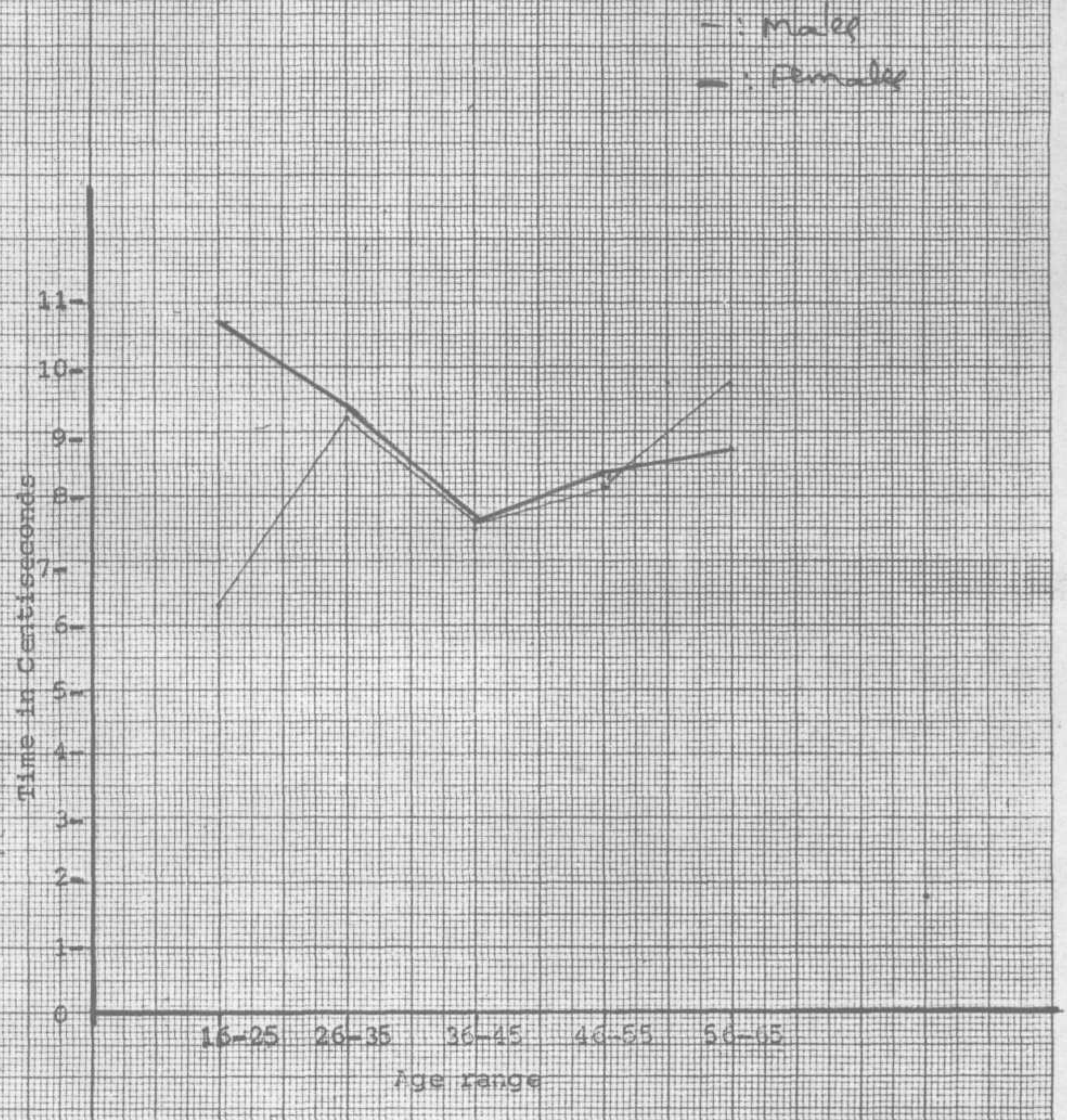
		16-25	26-35	36-45	46-55	56-65
Males		6.31	9.21	7.59	8.15	9.74
	SD	1.6	2.67	1.57	3.1	2.69
Female	Mean	10.7	9.4	7.59	8.24	8.7
	SD	2.6	3.9	1.96	2.64	2.3

Table-4.13: Mean and standard deviation of rise time(in centi seconds) in males and females.

	16-25	26-35	36-45	46-55	56-65
16-25		--	--	--	P
25-35			--	--	P
36-45				--	--
46-55					--
56-65					

Table 4.14: The insignificance of difference batween different age group of males on rise time.

* - Key is provided in Appendix-II



4.4: Rise time in males and females

The age groups 46-55 years (SD.3.1) and 56-65 years (SD of 2.69) have shown greater variabilities than other age groups.

Hence the null hypothesis stating that there is no significant difference in rise time as a function of age in males is partially rejected and partially accepted.

Females: The inspection of the table 4.13 and graph 4.4 show that the rise time decreases gradually as a function age upto 45 years of age and then increases from 46 years of age rise time in females. Further 4.13 table reveals that the age group, 16-25 years obtained longest rise time (mean rise time of 10.7 centiseconds) and the age group 36-45 years has shown shortest rise time (mean rise time of 7.59 centiseconds) when compared to other groups.

Table 4.15 reveals that there is no significant difference in rise time among different age groups. But whenthe age groups 16-25 years and 26-35 years compared with the age group 56-65 years. There is significant difference. The age group 56-65 years shows shorter rise time (8.7 centiseconds) when compared with younger age groups.

Age groups 26-35 years (SD of 3.4) end 46.55 years (SD.2.64) have shown greater variability than other age groups.

	16-25	26-35	36-45	45-55	55-65
16-25		--	--	--	A*
26-35			--	--	--
36-45				A*	--
46-55					--
56-65					

Table: 4.15 - The significance of difference between different age groups of females on rise time in speech.

* - Key is provided in Appendix-II.

Hence null hypothesis stating that there is no signlfi-cant difference in females as function of age with reapest to rime time in speech ia partially accepted and partially rejected.

<u>Sex difference:</u>- Males and females are compared with respect to rise time. The significant difference between males and females with respect to rise time is represented in Table 4.16.

The inspection of table 4.16 reveals that there is no significant difference males and females with respect to rise time. However the age group 16-25 years shows significant dlffe-rence at 0.05 level. In this group females have longer rise time than males.

Hence the null hypothesis stating that there is no sex difference with respect to rise time is partially accepted and partially rejected.

The results on the rise time of speech in both males and females indicate the following:

1. There is increase in rise time as a function of age in males But this increase rise time is gradual and not significant.

2. In case of females, rise time decrease as age increase, till 36-45 years then again increases upto 65 years. This change in rise time is not significant.

3. There is no significant difference between males and females with respect to rise time.

16 - 25		A
26 - 35	--	
36 - 45		A--
46 - 55	--	
56 - 65	--	

Table - 4.16: Significant difference between males and females on rise time in speech.

* - Key is provided in Appendix-II.

Fall time of speech: - The fall time of speech in centiseconds between the drop in intensity of the steady state to the stimulus to the end of stimulus.

The mean and standard deviation for the fall time of speech for all 3 test sentences, across the age range from 16-65 years for both males and females is given in table -4.17 and in the graph 4.5.

Males:- The inspection of table 4.17 and graph 4.5 reveals that there is gradual increase in fall time with the age in males. Table 4.18 dhows that there is no significant difference among different age groups in males Whan compared. But when tne age group 16-25 years is compared with the age groups 46-55 years and 56-65 years, there is significant difference. The age group 16-25 years shows shorter fall time. (9.2 centiseconds) than the age groups 46-55 years and 56-65 years.

Table 4.17 reveals that the age group 16-25 years shows lowest fall time (mean fall time of 9.2 centiseconds) and the age group 56-65 years has shown longest time (12.41 centiseconds).

Age groups 36-45 years (SD of 3.36) and 46-55 years(SD of 3.6) have shown greater variability than other age groups in males.

Increase in the fall time as function of age may be due to changes in the neuromuscular control due to aging process.

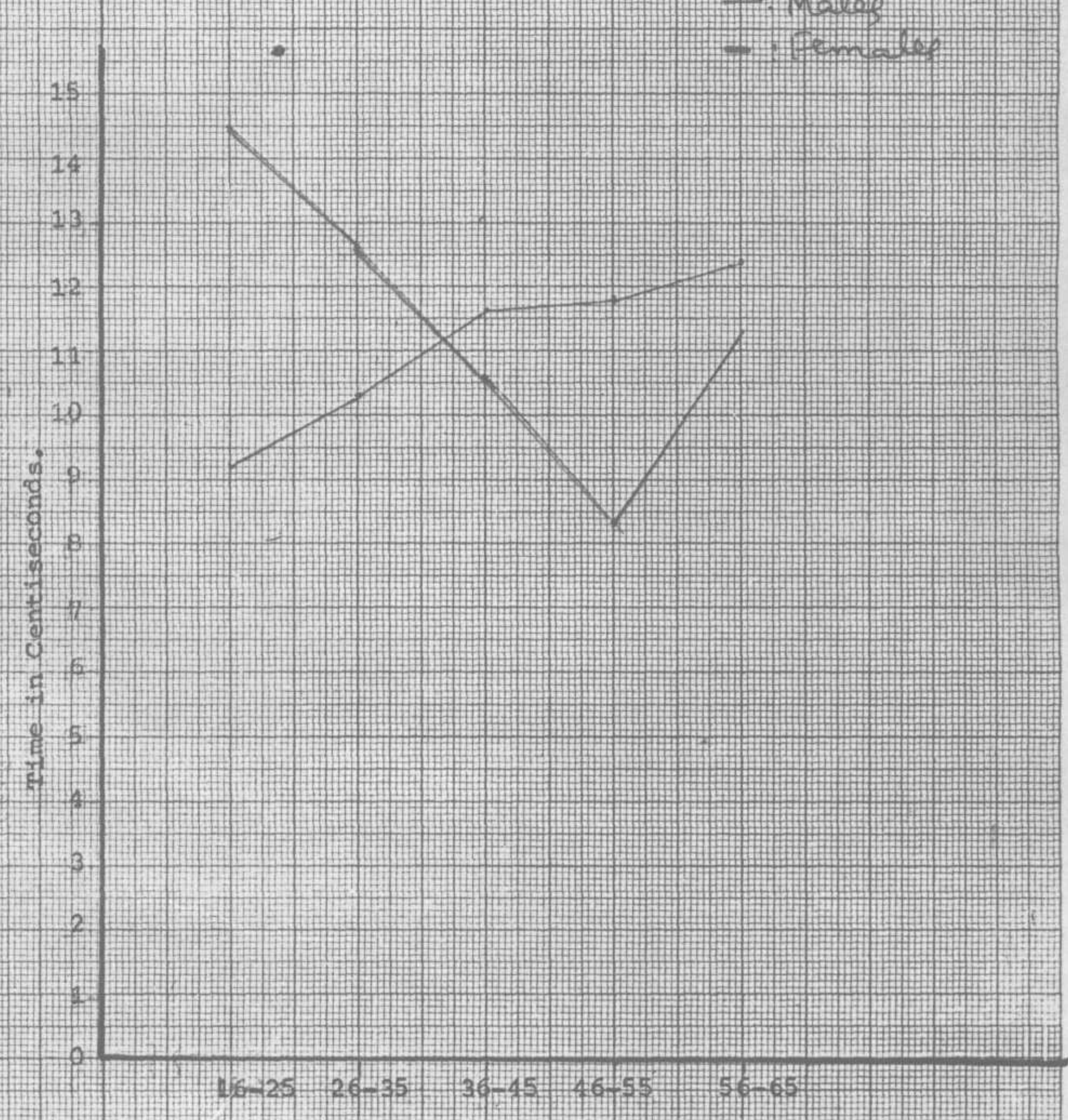
		16-25	26-35	36-45	46-55	56-65
Males	Mean	9.2	10.34	11.54	11.73	12.41
	SD	1.62	2. 15	3.36	3.6	2.98
Females	Mean	14.5	12.6	10.79	8.28	11.3
		8.6				
	SD		2.24	1.96	1.82	3.18

Table-4.17: Mean and standard deviations of fall time (in centiseconds) in speech in males and famales.

	16-25	26-35	36-45	46-55	56-65
16-25		—	—	A*	A*
26-35			-	—	A*
36-45				—	—
46-55					—
56-65					

Table-4.18: The significance of difference between different age groups of males on fall time in speech.

* - Key is provided in Appendix-II.



4.5: Fall time in males and females.

Hence the null hypothesis stating there is no significant difference in fall time as a function of ape in males is partly accepted and partly rejected.

females: Table 4.17 and graph 4.5 reveal that the fall time decreases as a function of age till the age of 55 years, then the fall time increases from the age 56 years to 65 years.

The inspection of table 4.19 shows that there is no significant difference in fall time as function of age in females, but when the age group 16-26 years is compared with the age group 56-65 years, the age group 16-26 years has shown longer fall time (14.5 centiseconds) than the age group 56-65 years (11.3 centiseconds).

The age group 16-25 years with SD of 8.6 has shown greater variability than any other age groups in female. A similar trend as in males is not seen in these groups of females.

Hence the null hypothesis stating that there is no significant difference in fall time in females as a function of age is partly rejected and partly accepted.

Sex difference: Significant difference between males and females with respect to fall time is represented in the table 4.20 reveals that there is no significant difference between males and females with respect to fall time upto the age of 45 years. From 46-65 years of age males show longer fall time than females.

	16-25	26-35	36-45	46-55	56-65
16-25		—	-	-	P
26-35			-	A	P
36-45				-	P
46-55					-
56-65					

Table-4.19: The significance of difference between different age groups of females on fall time in speech.

* - Key is provided in Appendix-II.

		--
16-25		
26-35	--	
96-45	--	
46-55	A*	
56-65	A*	

Table-4.20: Significant difference between males and females on fall time in speech.

* - Key is provided in Appendix.II

Hence the null hypothesis stating that there is no difference between males and females with respect to fall time is partly rejected and partly accepted.

The results on the fall time of speech show that:

1. In males fall time increases gradually as a function of age.
2. In ease females fall fall time decreases till the age of 55 years. After 56 years fall time starts increasing with the age.
3. There is no sex difference with respect to fall time till 45 years of age. From 46-65 years, males show longer fall time than females.

Vowel duration: - The duration of vowel /i/ occurring in the word "idu" in milliseconds was determined using high resolution signal analyzer. Mean and standard deviation is presented in Table 4.21 and graph 4.6.

Males:- Table 4.21 and graph 4.6 reveal that males show inconsistent variability with respect to vowel duration, with increase in age. The inspection of table 4.21 also reveals that the age group 26-35 years has obtained longest vowel duration (mean vowel duration of 103.7 m.sec) and this group shows the highest variability(i.e. SD of 23.2). The age group 36-45 years shows lowest vowel duration (mean vowel duration of 93.54 msec). Table 4.22 reveals that there is a significant difference in vowel duration of different age groups of males. But the changes in vowel duration with age has not shown any specific pattern.

Hence the null hypothesis stating that there is no significant difference in vowel duration as a function of age in males is partly rejected.

Females:- The inspection of table 4.21 and graph 4.6 show that there is a gradual increase in vowel duration through out from 16 - 65 years. Table 4.21 also shows that the age group, 56-65 shows the highest vowel duration (mean vowel duration of 110.14 msec) as well as highest variability (SD of 28.9) when compared to other groups. Table 4.23 reveals that there is significant difference in vowel duration as a function of age in females. Whe two age groups are compared.

		16-35	26-35	36-45	46-55	56-65
Males	Mean	96-75	103.7	93.54	90.7	97.3
	SD	13.08	23.2	18.72	18.2	13.6
Females	Mean	86.72	93.7	95.75	95.84	110.14
	SD	12.42	25.1	21.03	14.3	28.9

Table-21: Mean and standard deviation of vowel duration (in millisecondd) in males and females.

	16-25	26-35	36-45	46-55	56-65
16-25		P*	A*	P*	P*
26-35			P	P	P
36-45				P*	P
46-55					P
56-65					

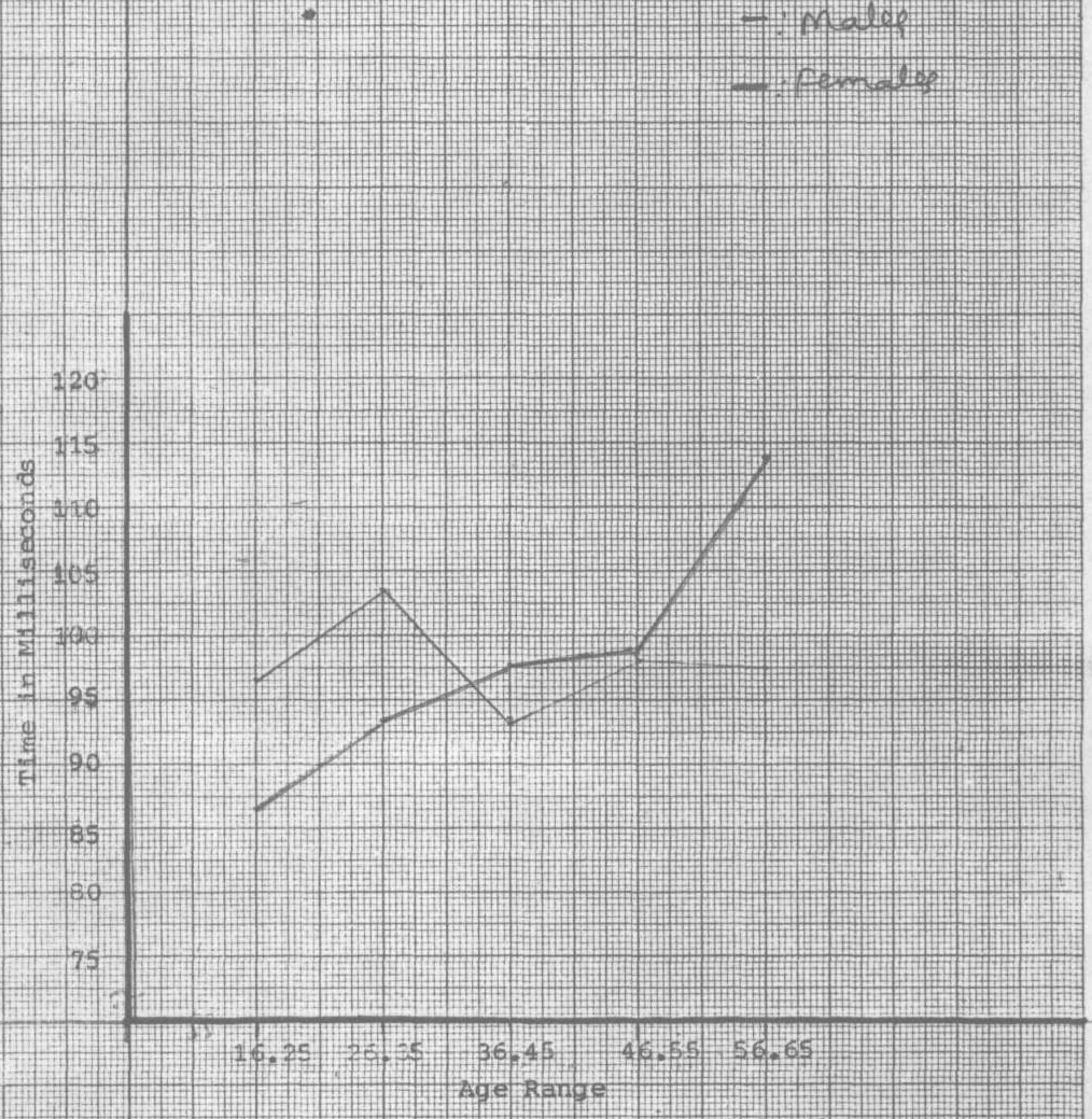
Table - 4.22: The significance of difference between different age groups of males on vowel duration.

* - Key is provided in Appendix-II.

	16-25	26-35	36.45	46-55	56-65
16-25		P*	-	A*	P*
26-35			P	P	P
36-45				-	P*
46-55					P*
56-65					

Table-4.23: The significance of difference between different age groups of females on vowel duration.

* - Key is provided in Appendix.II.



4.6: Vowel duration in males and females

Gradual increase in vowel duration in female as a function of age may be due to physiological changes which are related to aging process.

However Disimoni (1974) reports that the variability of duration tend to decrease with the age, a result which parallels the age related variation as in the study reported by Ejuchi and Hirch (1969).

Hence the null hypothesis stating that there is no significant difference in vowel duration as a function of age is rejected.

Sex difference:- The inspection of tables 4.21 and 4.24 reveal that when males and females are compared with respect to vowel duration, females show significantly longer vowel duration than males. This caa be attributable to fundamental frequency used by males and females. Lyberg (1981) reported a strong relation ship between vowel durations and fundamental frequency. Natara and Jagadiah (1984) have found a similar relationship between fundamental frequency and vowel duration. Rashmi (1985) has shown similar findings in children. She has reported longer vowel duration in females than in males.

Hence the null hypothesis stating there is no significant difference males and females with respect to vowel duration is partly accepted and partly rejected.

16-25	A*
26-35	P
36-45	P*
46-55	P
56-65	P

Table-4.24: Significant difference between males and females on vowel duration.

* - Key is provided in Appendix-II.

The results on the vowel duration show that:

1. Males show inconsistent variability with respect to vowel duration with increase in age.
2. In case of females there is a gradual increase in vowel duration from 16 years to 65 years of age.
3. Females show longer duration of vowel than males.

Harmonics:- The harmonics of the vowel /i/ in the word "idu" were found by feeding the word "idu" to the High Resolution signal analyzer, using the time scale. The cursor was moved to the centre of the envelope /i/ and the input function showing "Inst. Spectrum" was pressed. The display that appeared on the screen had a peak in each envelope. The spectrum of /i/ was display. The intensity level of each harmonic was determined by moving the cursor to each harmonic peak. The μ - parameter defined as ratio of the amplitude level above l000Hz and that below l000Hz (Frkjaer-Jensen and Prytz, 1976) was determined, by adding the intensity level at which each harmonic that occured above l000Hz and dividing it by the total intensity level of the harmonics below l000Hz for each subject. The mean and standard deviation of μ — parameter for each age group for males and females is presented in table 4.25. The mean values for both males and females are less than one indicating that the energy distribution below 1000Hz is more than the energy distribution above l000Hz. The inspection of table 4.25 and graph 4.7 shows that among males the age group 16-25 years has the highest ratio (mean μ - parameter of 0.76) and the age group 36-45 has the lowest ratio (mean μ - parameter of 0.72). Table 4.26 indicates that the μ - paramete is significantly different between a few age groups. The age group 16-25 years has significantly higher ratio than the age group 56-65 (.78)and the age group 26-35 has higher ratio (0.75) than the age group 56-65 years significantly (0.73).

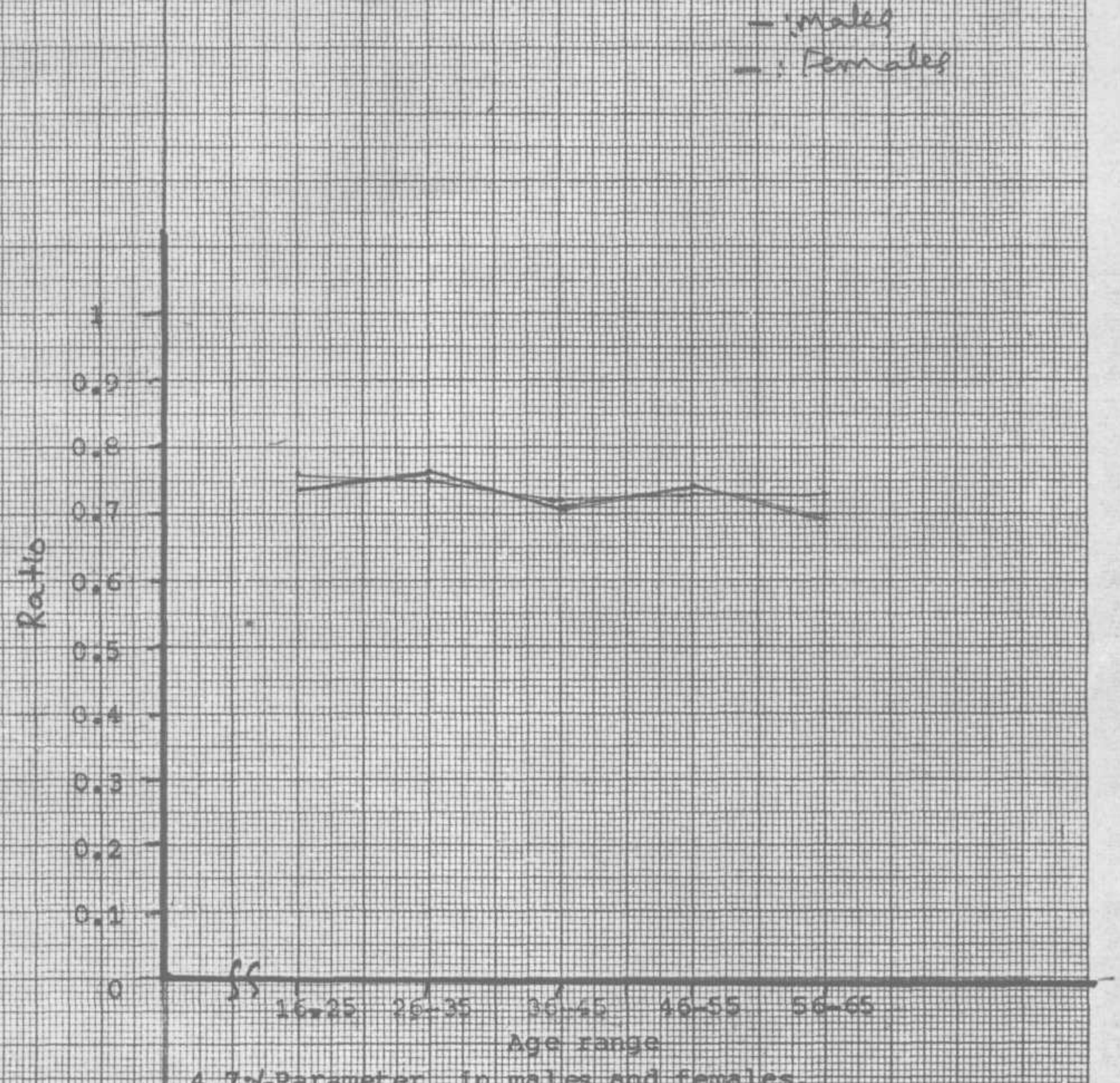
		16-25	26-35	36-45	45-55	56-65
Males	Mean	0.76	0.75	0.72	0.73	0.73
	SD	0.08	0.01	0.05	0.07	0.05
Females	Mean	0.74	0.76	0.71	0.74	0.7
	SD	0.03	0.04	0.05	0.06	0.08

Table 4.25: Mean and standard deviation of μ -parameter in males and females

	16-25	26-35	36-45	46-55	56-65
16-25		-	-	-	A
26-35			-	-	A
36-45				-	-
46-55					-
56-65					

Table 4.26: Significance of difference between different age groups of males on the μ -parameters.

* - Key is provided in Appendix-II.



4.7 α-Parameter in males and females.

Most of other age groups show no significant difference in μ -parameter between themselves. Hence the null-hypothesis stating that there is no significant difference in -parameter as a function of age in males is partly rejected and partly accepted.

Females: Table 4.25 reveals that in case of females the 26.35 age group has the highest μ -parameters (mean μ -parameter of 0.76) while the age group 56-65 years has the lowest μ -parameter (mean μ -parameter of 0.7). The significance of difference in the μ -parameter is presented in 4.27. The age group 16-25 years has significantly higher ratio than the age group 56-65 years. However there is no consistent significant difference in the μ -parameter as a function of age in the females also.

Hence null hypothesis stating that there is ao significant difference in the μ -parameter as a function of age of partly accepted and partly rejected.

Further table 4.28 shows that there is no significant difference between males and females in younger age group upto 55 year from 56-65 years there is significant difference in μ -parameter between males and females. Males show slightly higher ratio than females. Hence the null hypothesis stating that there is no significant difference between males and females at any age in th μ -parameter is partially accepted and partially rejected.

	16-25	26-35	36-45	46-55	56-65
16-25		-	-	-	A
26-35			-	-	-
36-45				-	-
46-55					-
56-65					

Table-4.27 Significance of difference between different age groups of females on the μ -parameters.

* - key is provided in Appendix-II

16-25-		
26-35	-	
36-45	-	
46-55		-
56-65	A	

Table-4.28: Significant difference batween males and males in μ -parameter.

* - key is provided in Appendix-II.

The study of the μ -parameter reveal the following:

1. The energy above l000Hz is less than the energy level below 1000Hz.
2. The μ -parameter shows no significant difference till the age of 55 years in both males and females. The 56-65 year age group has shown some difference when compared to 16-25 yearsgroup. The age group 56-65 years has shown lower μ -parameter than the age group 16-25 years in both males and females.
3. There is no significant difference in the μ -parameter between males and females in the age range of 16-55 years. But from 56-65 years, males have show higher μ -parameter than females.

The μ -parameter was recommended by Frokjaer-Jenson and Prytz (1970) as an indicator of voice quality. The results indicate that above 55 years show a significant difference in a comparison of the lower and higher parts of the speech spectrum, which indicate that there is change in the voice quality at this age in both males and females. The results therefore indicate that voice quality change after 55 years of age which can be attributable to changes in the supraglottal resonator and vocal system due to aging process. This might lead te an increase in noise components in the higher parts of the speech spectrum.

there by suppressing harmonics. As Frokjaer-Jenson and Pryts have pointed out, the coming years may show if registrations of theo μ -parameter will turn out to be a useful aid in phoniatric and logopedic routine diagnosis during speech therapy.

Results of present study summarized in table 4.29 and graphs 4.8 and 4.9. Any physiological, psychological or pathological changes in the body are raflected in voice. Acoustic analysis as Hirano (1981) has pointed out seems to be the key for unlocking many Myths about voice and voice disorders. Before applying acoustic analysis for the investigation of causes and physiology of abnormal voice, it is essential to know the operation of acoustic parameters is normal voice. Currant research suggests that acoustic analysis of voice may present the first accurate information about pathological changes in larynx (Von Leden and Koike, 1970; Murry and Doherty, 1980). The simplic of the acoustic analysis may suggest that it may be an ideal screening device for the detection of laryngeal disease. Therefore it is essential to investigate the effects of age and sex. On the acoustic parameters before they can be applied to the clinical situations. The present study ia one such attempt to determine the age and sex related differences in acoustic aspects of the speech in adult Indian population.

The S.F.F. gradually increases with the age it increase till the 55 years in case of females than later shows decrease. This

Table 4.29: Summary of the parameters with respect to age and sex.

Parameter	Trend with increasing age.	Sex difference within same age group
l. Speaking Fundamental frequency.	Males:Gradually increases Females:Insreaaeg till 55 years, from 56 years S.F.F. lower with increase in age.	Significantly higher in females.
2.Frequency range.	Male: Increases till the age of 45 years then from 46 years it decreases with age. Famales:Increases with the age.	Females use greater frequency range.
3.Intensity range	Males: Decreases with the age. Female: Inconsistent.	Significant only at 16-25 years, 26-35 years age group, otherwise no significant difference.
4.Rise time	Male: Gradual increase with the age. Females: Decreases with the age.	No significant difference

Contd.....

5. Fall time	Males: Decreases with the age. Females: Decreases with age till 55 years and from 56 years fall time increases with the age.	There is no significant difference till 45 years. From 46-65 years, males show longer fall time the females.
6. Vowel duration	Males: Inconsistent Females: Decreases with the age.	Significantly longer in females.
7. μ -Parameter	Males: Lowers at 56 years of age. Female: Decrease in ratio from 56-65 years.	No difference.

may attributed to the endocranial Changes and other changes in the tissues of the phonatory and resonatory systems.

It is surprising to note that the frequency range in females increase with the age where as males show such increase only till the age of 45 years, after which they show decrease. It is also interesting to note that females use greater frequency range than males throughout age range studied. Factors responsible for these changes in males and females are not known. These findings warrant further investigations on frequency range in adult population and also the factors related to frequency range.

The intensity range has decreased with age in case of males and females have shown inconsistent results. The factor operating in determining the intensity range in speech particularly in uttering neutral sentences as used in present study. Therefore it is recommended tnat larger speech sample with greater adult population be used to note the actual course of intensity range with age and also to identify the factors operating in determining intensity range.

Rashmi (1985) has reported that the rise time decreases and Fall time increases as a function of age upto the age of 14 years. She attributes this to the increase in the control of the laryngeal and respiratory muscles. The present study has indicated that the males show a gradual increase in rise time and gradual decrease in fall time with age. Where as the female subjects have shown decrease in both rise and falltlme. In the above explanation offered by Rashmi (1985) does not find an application with adults in the light of the results presented by the present investigation. Therefore it will be intensity to investigate these two aspects namely rise and fall time in speech in adults and also in children and to find an explanation which will be applicable to both adults and children.

Vowel duration which has strong relationship with frequency and intensity, other factors being constant has been found to vary inconsistently with age in males where as the same has shown consistent decrease with the age in case of females. This again warrants further investigation.

Ratio remains almost constant between consecutive age groups, but shows a gradual decrease with the age. Thus, it has shown a significant difference between youngest group and oldest group studied in this study. The μ -parameter consider to be reflecting the quality of voice which depends on the vocal cord vibration and resonatory system. Thus the Changes in the phonatory system and resonatory system with the age may be responsible for the changes seen in μ -parameters. With increasing age.

Thus, these parameters may be one way of cheracterizing age related changes in voice. This information will be useful in identification, diagnosis and treatment of voice disorders. Thus the results of present study not only provide information regarding age related changes in voice interns of acoustic parameters but also give rise to few questions. The study also indicates the possibilities of using these methods for diagnosis and differential diagnosis of various voice disorders and thus opens up new avenue for the study of age related changes in voice disorders.

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CHAPTER- 5

SUMMARY AND CONCLUSIONS

Speech is a neuromuscular activity. In other words, the output of this activity is the acoustic signals, which are used for communication - as speech. The acoustic characteristic of speech have been found to vary with age. These acoustic characteristics on various aspects of speech production indicate the accuracy of control changes with the age (Kent, 1976).

"Today we are able to measure the acoustic or audible aspects of voice with sophisticated equipment. The voice print analyzer,sonograph, airflow meter, pressure recorder, and com-perized model of the vocal tract enable investigators to confirm earlier empirical findings and unearth new aspects of vowel sound Characterization. The physiological aspects of sound production such as breathing patterns, vocal attack, vocal fold vibration, and some resonance qualities can be revealed by acoustic means" Bonch, 1982.)

The acoustic analysis to study the changes in speech as a function of age in adults has been found to be useful as such studies reflect.

1. The adjustment of phonatory appratus.
2. The shaping of the vocal tract, and

3. The timing and coordination of articulation and neuromuscular changes of speech mechanism. This information, is of importance in identification, diagnosis and treatment of various speech and voice disorders.

The acoustic analysis has been considered to be useful in Knowing more about disorders in adults and thus in the treatment of disorders.

The present investigation was therefore undertaken to study certain acoustic parameters of speech, recommended by Hirano (1981),nameiy:

1. Fundamental frequency
2. Frequency range
3. Intensity range
4. Rise time
5. Fall time
6. Intensities at Harmonics.
7. VOwelduration.

These parameters were studied in a sample of one hundred adults both males and females, ranging in age from sixteen years to sixtyfive years, who were normals in terms of their speech, language and hearing.

Data on the repetition of three Kannada sentences "idu pa.pu","idu ko:ti" and "idu kempu banna" were recorded. Each adult was given three trials. Average of these samples of the nine trials was used for analysis.

The speech samples were fed to the pitch analyzer (PM-100) to obtain speaking fundamental frequency, frequency range, in speech,intensity range in speech, rise time and fall time of speech.

To measure the vowel duration and the harmonics, the word "idu" was fed to the high resolution signal analyzer. The duration of the vowel /i/ and the harmonic occurring in it were measured, for all one hundred adults.

The data thus obtained was subjected to statistical analysis, in order to determine the mean, standard deviation and significance of difference between the sexes and different age groups.

After statistical treatment, the following conclusions have been drawn.

1. <u>Speaking fundamental frequency:</u>

a. There is a gradual increase in S.F.F. with increase in age in males. The changes in S.F.F. are more at old ages i.e. above 55 years. It increases from l39.7Hz at 16-25 years to 149.76Hz at 56-65 years.

b) There is a gradual increase in S.F.F. with increase in age till 55 years in females. From 56 years, the S.F.F. lowers in females. It increases from 224.5 Hz at 16-25 years to 258.7 Hz, at 46-55 years and decrease to 234.73Hz at 56-65 years.

c) There is a significant difference between males and females in S.F.F. Males use lower S.F.F. than females.

2. Frequency range in speech:

a) Males show an increasing trend in the range of fundamental frequency with the increase in age upto age of 45 years. From 46-55 males show decreasing trend in the frequency range of speech with increase in age.

b) Females also exhibited an increasing trend in the range of fundamental frequency used in speech as a function of age.

c) Females use greater range of fundamental frequency in speech than males.

3. Intensity range:

a) There is a gradual but insignificant decrease in range of intensities in speech in males.

b) Female subjects show inconsistent intensity range in speech.

c) Difference in the range of intensities between two sexes is not significant.

4. Rise time of speech:

a) There is a gradual increase in rise time as a function of age in males is seen.

b) In ease of females, rise time decreases as age increases till 36-45 years, then increases upto 65 years.

c) There is no significant difference between males and females in rise time.

5. Fall time of speech:

a) In males fall time increases gradually as a function of age.

b) In case of females fall time decreases till the age of 55 years After Which in starts increasing.

c) There is no difference between males and females with respect to fall time till 45 years of age. From 46-65 years, males show longer fall time than females.

6. Vowel duration:

a) Males show inconsistent variability with respect to vowel duration with increase in age.

b) In case of females there is a gradual increase in vowel duration from 16-65 years of age.

c) Females show longer duration of vowel than males.

7. Harmonies:

a) The energy level above l000Hz is less than energy level below 1000Hz in both males and females.

b) The μ-Parameter shows no significant difference till the age of 55 years in both males and females. The age groups 56-65 years show significant difference when compared to 16-25 years. The age group 56-65 years show lower μ -parameter than the age group 16-25 years in both males and females.

c) There is no significant difference in the μ -parameter between males and females in the age range of 16-55 years. But from 56-65 years, male show higher μ -parameter than males.

Recommendations:

1. Study may be carried with larger sample in each age group.
2. The analysis could be extended other acoustic parameter.
3. The same parameters can be studied with clinical adult population to explore clinical utility of this information.

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APPENDIX I

Pitch Analyzer PM -100

The Pitch Analyzer is a microprocessor controlled device which has been designed for use in a wide range of speech and language applications.

Various pitch and intensity traces, as well as, the digital data are displayed on a IV monitor. The frequency and or intensity curves may be transferred to output printing devices in an analog or digital form, either on a Mingograph or an X-Y plotter.

The operating range of the instrument is from 70-l000Hz.

In this unit a level of 47 dB is equal to the audiotelephony standard of 0 dB. This, in turn, is approximately an audiometer level of 130 dB.

The sample duration ranges from 1 to 9 seconds.

Allows entry of data into the upper or lower half of the screen, and is provided with two cursors - an upper and a lower cursor, which may be moved independently.

High Resolution Signal Analyzer (B & K 2033)

The HRSA (B 6 K 2033) consists of a combined transient recorder and Fourier analyzer. The transient recorder has a 10 K sample memory (1K = 1024) and is equipped with an extremely flexible trigger allowing the 2033 to analyze both continuous and transient data. The transient recorder combines with the

Fourier Analyzer to give the 2033 two modes of operation- Base band mode and High Besolutlon mode.

It has a large 11" screen for display of time function, instantameous or averaged spectrum, ratio of spectra, or spectrum comparison.

Frequency Range : 11 base band full scale frequencies from 10 Hz to 20 KHZ la 1-2-5 sequence.

Dynamic Range: Full displaced spectrum dynamic range greater than 20 dB.

Triggering: Internal and external triggered operation with flexible pre- and post trigger time delay (from 0.0 to 64 K samples).

Averaging: Linear, exponential or store max. averaging over 1-2048 spectra with automatic elimination of over-loaded input data.

Scam Analysis and Scan Average: Unique scan analysis for speed up/slow down of events. Scan average producing a 400 line averaged spectrum of hole of l0K time function. Invaluable to analyse long transient and non-stationary signals.

Wide angle Zoom: Built-in non-destructive zoom with possibility of measuring a 4000 line spectrum (wide angle zoom). The zoom transformation takes only about a second.

Storage: Protected memory for storage of displayed spectra or spectra entered digitally.

Spectrum comparison: Slow and fast alternate diaplay of input and stored spectra.

Cursor: Versatile cursor function for indication of time or frequency and level af selected line.

APPENDIX II

Key to the Significance Tables as a function of age:

- No significant difference at 0.05 level of significance

A Older age group showing a significantly lower value than the younger age group at the 0.05 level of significance.

*A Older age group showing a significantly higher value than the younger age group at the 0.05 level of significance.

P Older age group showing a significantly lower value than the younger age group at the 0.01 level of significance.

value

*P Older age group showing a significantly higher value than the younger age group at the 0.01 level of significanve.

Key to the signifcance tables showing sex differences

- No significant difference between males and famales at the 0.05 level of significance.

A Males show significantly lower values than females at the 0.05 level of significance.

*A Males show significantly higher values than the females at the 0.05 level of significance.

P Males show significantly lower values than the females at the 0.01 level of significance.

*P Males show significantly higher values than females at the 0.01 level of significance.