EFFECT OF SAMPLE DURATION AND TEMPORAL RESOLUTION ON PERTURBATION MEASUREMENTS

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Dissertation submitted as part fulfilment for the second

year M.Sc. (Speech and Hearing) to the

University of Mysore

All India Institute of Speech and Hearing
MYSORE - 570 006.
1994.

Dedication

This Dissertation is dedicated to
My dearest friend and partener
With enormous LOVE.

CERTIFICATE

This is to certify that the dissertation entitled **"EFFECT OF SAMPLE DURATION AND TEMPORAL RESOLUTION ON PERTURBATION MEASUREMENTS"** is the bonafide work in part fulfilment for the degree of Master of Science (Speech and Hearing) of the student with register No. M 9220.

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CERTIFICATE

This is to certify that the dissertation entilled **"EFFECT OF SAMPLE DURATION AND TEMPORAL RESOLUTION ON PERTURBATION MEASUREMENTS"** has been prepared under my supervision and guidance.

Mysore
1994.

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DECLARATION

This dissertation is the result of my own study undertaken under the guidance of Mr. C.S. Venkatesh, Lecturer 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.

Mysore
1994.

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ACKNOWLEDGEMENT

I am gratefully indebted to my guide and teacher to Mr.C.S. Venkatesh, Lecturer, Department of Speech Sciences, All India Institute of Speech and Hearing, Mysore, for having provided me with immense help, strength and support in the completion of this study. Sir, you have introduced me to the field of Research, have guided me through the the dark allayes of it and encouraged me to reach the goal. Thank you for making me more confident in the field of Speech Sciences. Thank you very much, Sir.

My special thanks go to Dr. (MISS) S. Nikam, Director, A.I.I.S.H, Mysore for permitting me to carry out this study.

I express my deepest gratitude and heart ful of thanks to Dr. N.P. Nataraja, HOD, Dept. of Speech Sciences for permitting me to make use of computers and instrumentation in the department thereby helping me to carry out this study.

Mummy and Baba - Thank you very much for having always made me feel special to you. Thank you for the faith and confidenced that you have in me.

Babi & Ibrahim Bhai, Misbah and Moosa - thank you very much for the love that you shower on me.

Thanks to Munni and maqsood; Rana, Lubna, Huma and Madiha - for being a source of pleasure to me.

My dearest brothers - Chottu and Abbu, I am privileged for being your brother.

My lovely sisters - Tazzu and Pari - thank you for the love and respect that you render to me.

Ranjana - thank you, even if you are not around, the thought of having spent time with you keeps haunting in my memories and makes me nostalgic.

Balaraju, Harisadhan, Pitu, Zaner and Gitanjali - Thanks for memories given to me.

Thank you, Sidheshwar, Sunil & Nandu for being beautiful friends for last two years.

Renu Bhat - Thank you, your credit in finishing this dissertation is unaccountable.

Thank you Petula and Suma for making me successful in pulling your legs.

Thank you Farah for I got to know a sweet, little and cute girl.

My classmates - Thank you for everything.

Batru, Mahadeva and Pandey - Food cooked by you has kept me hale and hearty in Mysore. Thank you.

Library staff - Thank you for searching for books patiently and providing help whenever I required.

Suchi dear your contribution to my life is ineffable and I am grateful to you for all the help you have provided in the completion of this dissertation and the showering of your love which has made me what I am today. Your friendship of two years has helped me in many ways which none can understand.

CHAPTER -I

INTRODUCTION

CONTENTS

INTRODUCTION

"Voice is the laryngeal modulation of pulmonary air stream which is further modified by the configuration of vocal tract". (Michael and Wendahl, 1971).

Voice plays an important role in speech communication. The production of voice involves a complex and precise control by the central nervous system, on a series of synchronous events in the pecipheral phonatory organs namely respiration, phonation and resonation.

Hence, the anatomical and physiological deviation in any of these systems would lead to a voice disorder (dysphonia). The incidence of voice disorder is 0.6% of general population. Nearly 9.8% of cases, who visited the AIISH had voice disorder during 90-91, (AIISH Annual report 90-91). So the clinician should be equipped with an appropriate diagnostic tool which enables him/her to assess and detect the voice disorders as early as possible. The treatment of patients suffering from dysphonia depends upon the ability to assess the type and degree of voice disorder and also to monitor the patients progress through the treatment.

There have been many attempts over the years to find different voice parameters and objective methods that aid in early detection, diagnosis and treatment of voice disorders. They are acoustic, aerodynamic and perceptual measurements are promising as a future dignostic tools and also in mangement of voice disorders. Healthy voices have nearly constant pitch, loudness and quality during phonation. On the contrary subjects with the laryngeal dysfunction exhibit variations in frequency and intensity during phonation. Fundamental frequency and intensity perturbation measurements are very sensitive to the presence of laryngeal disorders.

Acoustic analysis of the voice signal may be one of the most attractive methods for assessing phonatory function or laryngeal pathology as it is non-invasine, objective and quanlitative. Many acoustic parameters derived by various methods have been reported to be useful in differentiating between the pathological voice and normal voice. [Crystal and Jackson (1970), Von Leden and Koike (1970), Koike (1973), Nataraja (1986) and Pinto and Titze (1990)] .

Small variations in frequency and intensity i.e., cycle to cycle variation in fundamental frequency (Pitch perturbation or Jitter) and cycle to cycle variation in intensity (amplitude perturbartion or Shimmer) are shown to be natural ingredients in normal voice (Liberman, 1961). Infact such perturbations are important for the natural quality of voice. These variation in pitch and amplitude are probably due to the neuromuscular, phonatory control system.

There are several factors which influence the pitch and amplitude perturbation measures. They are:

1. Sample duration.
2. Temporal resolution (sampling frequency)

3. Pitch extraction method.
4. Type of microphone.

However there is no study available in literature which have reported the comparison of pitch and amplitude perturbation measurement across different sample durations. Similarly, no attempt has been made to compare the pitch and amplitude perturbation measures obtained with two different temporal resolutions.

The present study is aimed at studying the effect of duration of voice sample and temporal resolution of perturbation measurements. The sample durations of 0.5 secs, 1 sec, 2 sec and 3 sees and temporal resolution of 8,000 Hz and 16,000 Hz are compared for their efficacy in the measurement of frequency and amplitude perturbations.

CHAPTER - II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Vioce has been defined as "the laryngeal modulation of the pulmonary airstream which is further modified bythe configuration of the vocal tract" (Michel & Wendhal, 1971).

Vioce basically has three parameters i.e., frequency, intensityand quality. Quality of vioce is partially dependent on pitch and pitch inturn depends on the vibration of vocal folds. Thus it becomes extremely essential to study the vibratory movement of the the vocal folds for a thorough underestanding of normal and abnormal voice production.

Traditional methods of vocal assessment have been heavily dependent upon visual inspection of the vocal folds and subjective descriptions of perceptual judgements of patients' voice quality (yanagihara,1967). But, visual inspection gives little information regarding vocal fold vibration whereas perceptual judgements lead to confusion of concepts and terminology and questionable test-retest and inter-rater variability (Koire, 1969; Yanagehara, 1967).

High speed cinematography (Von Liden et.al., 1960, electroglottography (Fourcin and Abberton, 1977) and sound spectrography (Routal et.al, 1975) have been used to relate vocal cord vibrations to voice quality. Results have been promising, however, there have beer problems with intrumentation, methodology and analysis. In addition, invasive techniques like endoscopy, stroboscopy and the like present varying degrees of risk and discomfort for the patient (Korre et.al, 1977). Therefore, researchers are focussing on acoustic analysis because of the following:-

1) Laryngeal pathology alters normal vibratory pattern of vocal folds.

2) There exists a relationship between vibratory pattern of vocal folds and certain parameters of acoustic waveform generated by this vibration.

3) Acoustic analysis is non-invasive and provides objective and quantitative data. (Korire et.al,1977).

Many acoustic parameters derived form various methods have been reported to be useful in differentiating between pathological and normal voice. Of the many acoustic parameters that are useful in the diagnosis of voice disorders, probably pitch and amplitude perturbations have been extensively studied currently by several researchers.

PITCH AND AMPLITUDE PERTURBATIONS :

The production of voice is a complex process which requires precise control by the central nervous system of a series of events in the peripheral phonatory system. Healthy voice have nearly constant pitch, loudness and quality, whereas, subjects with vocal pathology exhibit fluctuations during phonation.

These fluctuations in the voice give important information regarding the presence, absence and perhaps to some extent, the nature of vocal pathology. These fluctuations can be grouped into two categories, namely. (1) gross fluctuations, and (2) fine fluctuations. Examples of gross fluctuations are speed and extent of fluctuations whereas shimmer and jitter factors represent fine fluctutions. These jitter and shimmer parameters are also called as pitch and amplitude perturbations respectively.

Presence of small perturbations or irregularity of glottal vibration in normal voice has long been recognized through oscillographic analysis of acoustic pressure waves and through laryngoscopic high-speed photographic investigations (Murry and Von Leden, 1958; Scripture, 1906; Simon, 1927; Von Leden, Murry and Timcre, 1960). Variations of fundamental frequency (period) and amplitude of successive glottal pulses in particular, are often refered to as "jitter" and "shimmer" respectively [Heiberger & Horii, 1982]. Earler methods of analysis for "jitter" and "Shimmer" were oscillographic analysis, glottal wave function, analysis via caryngoscopic high-speed photography.

Because of the minute nature of the parameters and because of limitations of above measurement techniques, the measurement of pitch and amplitude perturbations were time consuming and difficult. Because of this normative date on jitter and shimmer have been slow to accumulate. With the invention of computers and compater based techniques, the methods of measuring shimmer and jitter has become more precise and a quick.

JITTER :

The cycle-to-cycle variation is period that occurs when an individual is attempting to sustain phonation at a constant frequency has been termed as jitter or pitch perturbation [Michel & Wendahl, 1971]. This provides an index of stability of the phonatory system.

Jitter measurements are concerned with short term random variations and not with the systematic voluntary variations due to stress, intonation etc. In other words, jitter is a measurement of how much a given period differs from the period that immediately follows it, and not how much it differs from a cycle at the other end of the utterance.

Jitter is highly sensitive to pathological changes in the phonatory process. Studies have found that even the normals present some amount of jitter. But pathological voices have higher magnitude of jitter.

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There are a number of methods for obtaining jitter measurements and when actual measurements are done, a muber of alternative methods of data reduction are available to the investigator (Heibergr & Horii, 1982). They differ among themselves in either one or more of these factors like basic assumption regarding the sources of perturbation, the rationale behind the techniques, statistical treatment of data, the degree of automaticity of the computation, magnitude Vs direction of the perturbation, fundamental frequency related Vs connected speech. Each of these methods has its reltive advantages and drawbacks.

Earlier methods of jiter analysis were oscillographic analysis and glottal area function analysis via laryngoscopic high speed photography. These methods were slow and laborious and needed a lot of skill and patience on part of the researcher.

Hence they started developing faster and easier methods as well as automatic instruments for this purpose Jacob (1968) used pitch synchronized counters. Howard (1965) developed a device for perturbation detection. Kay elemetrics company developed 'visipitch' with jitter indicators. These advances also brought precision to the jitter measurement.

More recently computers have been put to use for automatic tracing of individual cycle and calculating jitter parameters (David, 1976; Horii , 1975, 1979, 1980) and this has revolutionized this area of investigation giving a tremendous momentum to it.

Fundamental frequency histograms and durational differences histograms are the precursors of jiter measures. Fundamental frequency histogram is nothing but a bar diagram of the ocurances of fundamental frequencies in the sample. Durational differences histogram is simply a bar diagram of the absolute differences between the two consecutive pitch periods in the sample.

Coleman (1960), Lieberman (1961,1963) and Moore and Thompson (1965) were among the first to report jitter measurement from speech sample.

Lieberman (1961,1963) used the durational difference histograms for his studies and gave as index as pitch perturbation, which he called as "Perturbation". He defined it as the percentage occurance of pitch period differences larger than half millisecond in a vocalic segment of connected speech. He believed that perturbations less than half millisecond were due to phase changes occuring during the evolution of the vocal tract transfer function. He claimed that perturbation factor is useful in the detectionof laryngeal disease (Lieberman 1963). The most important facet of this study was that the variability of the fundamental period was statistically accounted for. A similar parametric statistical procedure was adopted by many authors in future.

The simplest calculation method that has been used to quantify pitch perturbation is "mean Jitter" which is the average absolute difference in fundamental period between adjacent pitch pulses. This is measured in miliseconds. Zemlin (1992) reported the mean jitter ranging from 0.2 to 0.9 msec for a group of subjects with multiple sclerosis.

Moore and Thompson (1965) found mean jitter values of 0.30 msec, for a severely hoarse voice and 0.06 msec, for a moderately hoarse voice. Horii (1985) reported the mean jitter value for adult males ranging from 14-40 years to be 0.0176, 0.102 and 0.078 msec, for /a/, /i/ and /u/ respectively. Kare and Wellen (1985) reported the mean jitter verying from 0.0023 to 0.0472 msec, with a mean of 0.0123 msec, for children of age ranging from 6 to 11 years with vocal nodules. Sridhara (1986) studied the mean jitter in 30 young normals using /a/, /i/ & /u/ vowels and reported the following data;

Table 2.1 Mean values of "mean jitter" (milliseconds)

Sex	/a/	/i/	/u/
Male	0.065	0.110	0.067
Female	0.058	0.030	0.048

But, this is an absolute measure and tends to be proportional to the mean fundamental period (Hollien et. al, 1973, Horii, 1979, Lieberman, 1963).

This is the reason why the various other indices of jitter are computed with reference to the fundamental frequency of the speech utterance. Pitch perturbation is often represented as a percentage. Percent jitter is defined as mean jitter in milliseconds divided by the mean period in milliseconds, multiplied by 100.

The results of the study conducted by Moore and Thompson (1965) when converted into percentage jitter gave 4.9% and 1.4% for a severe and a moderate hoarse voice respectively. Jacob

(1968) found a median jitter of about 0.6% for phonations produced at a comfortable pitch and intensity level. Hollien et al (1973) found 0.5% and 1.1% jittter for 102Hz and 276Hz sustained vowel phonation. Results of jitter analysis of normal sustained phonation by young adults indicates that jitter in the order of 0.5% to 1% is typical (Hollien et al 1977; Horii, 1979). Smith et al (1978) established a range from 5.4% to 14.5% of jitter for esophageal voice. Nataraja and Savitri (1990) reported that a jitter greater than 3% is considered abonormal.

But the value of percent jitter is vey small in case of normal in sustained phonation. So Jocob (1968) used another index termed us "Jitter ratio", which can be obtained by multiplying the percent jitter by 10.

i.e., Jitter Ratio = % jitter X 10.

Later, Smith et.al (1978) and Horii (1979) also used the same index for their studies. Horii (1979) reported a range of 5.3 to 7.6 of jitter ratio for six normal males age ranging from 28 to 43 years.

Hecker and Kreul (1971) assumed the direction of perturbation, rather than the magnitude, more sensitive to the pathological changes and presented another perturbation measure, the "Directional Rerturbation Factor", defined as the percentage of period time difference between adjacent periods which differed in algebraic sign. They used the voiced segments of one phrase taken from the "Rainbow Passage" instead of sustained phonation. This may be regarded as a method of non-parametric statistics. Hecker & Kruel (1971) found that the directional perturbation factor could seperate 5 patients with cancer of vocal folds from 5 normal speakers whereas Lieberman's perturbation factor did not seperate the two groups of speakers. Miggins and saxmen (1989) compared the intrasubject variation across sessions of three measures of Jitter and reported that directional perturbation factor (DRF) was more temporally stable measure as compared to jitter factor and pitch perturbation Quotient.

Hecker & Kreul (1971) found that DRF ranged from *21.1%* to 39.2% for normal speakers and from 42.5% to 54.0% for the pathological speakers. These findings were cross checked by Murry and Dohetry (1980) who extrailed DPF for the normel & \a\ produced by 5 normal speakers and 5 cases of laryngeal cancer. The mean DPF for the normal subjects was 58.5% with a range of 45.8% to 65.3% the subjects with laryngeal cancer had a range of 55.1% to 76.7% and a mean value of 64.5%. The values from this study are substantially higher than the corresponding values of Hecker and Kruel (1971). This difference in the two sets of data can be attributed to both the test materials utilized and to the analysis techniques of the researchers.

Sorenson and Horii (1984) reported the most complete available data obtained from 20 men and 20 women and this may be considered as tentative norm:

Table 2.2

Sex	\a\	\i\	\U\
Male	46.24	46.37	49.26
Female	48.79	52.04	52.77

Hollien et al (1973) proposed an index called Jitter Factor, which was similar to the Jitter Ratio. The Jitter factor is defined as the mean difference between the frequencies of adjacent cycles divided by the mean frequency multiplied by 100. The only major difference between the Jitter Factor and the Jitter Ratio is that the JF is calculated based on the fundamental frequency data where as the JR is computed from the period time data. Another difference is regarding the multiplier used in the computation. The JF uses 100 as multiplier where as the JR uses 1,000.

Hollien et. al (1973) established the values of JF for normal adult males of age ranging from 21 to 37 years and reported the mean JF to be 0.47, 0.53, 043 and 0.97 for 102 Hz, 142 Hz, 198 Hz and and 276 Hz of sustained phonation. Later on Murry and Doherty (1980) reported higher JF of 0.99 for the elderly male group of age ranging from 55 to 71 years whose mean Fo was 115.3 Hz.

Koike (1973) proposed another index called as the relations average pitch perturbation (RAP). This is also called as frequency perturbation quotient (FPQ) or pitch perturbation quotient (PPQ). In contrast to Lieberman's measurements in which perturbation exceeding a fixed absolude limit (0.5 ms) mere counted, Koike concidered all the nariations in this measure. It is evident that steady normal sounds normally exhibit slow and relatively smooth changes in the period along with the abrupt, rapid and quasi random shifts (Koike, Takanashi & Calcaterra, 1977) While measuring Jitter. Therefore, they suggested to use average absolute perturbations to minimize the effects of slow and smooth changes. He measured the perturbations from a smoothed trend line for this purpose. In order to obtain this trend line he recommended either 3 point or 5 point averaging at each cycle except at the two extreinilies of the vowel sample.

The RAP is defined as the ratio of a moving average of fundamental period differs to the average fundamental period where the length of the moving average is equal to either 3 or 5 periods.

Koike (1973) found that the mean frequency RAP for 30 adult speakers of both sexes and various ages was about 0.0046 for the mid section of a sustained \a\ normal. Later on, Takahashi and Kokie (1976) reported a mean RAP values of 0.0057 for 7 males and 0.0061 for 2 females.

Koike (1973), Takahashi & Koike (1976), Koike et. al (1977) and Danis (1979, 1981) applied this technique and demonstrated the feasibility of screening laryngeal pathology like tumour, unilateral paralyses.

Deal and Emaunel (1978) used a statistical technique of a coefficient of variation for the computation of another measure of Jitter called as period variability. Index (PVI), the PVI is defined as the mean of the squares of the deviation of each period in the sample from the mean period divided by the square of the mean period multiplied by 1,000.

They reported mean PVI of 0.4412, 0.4898 and 0.4451 for \a\, \i\ and \u\ vowels respectively sustained for 7 secs. at 75 dB SPL for 20 adult males.

Gubry nowicz et al (1986) analysed running speech from 143 healthy and pathological speakers. The relative differences between successive period times were calculated. The dispersion and asymmetry of the distribution of these relative defferences were used in the classification of voices. By using a diagnostic model featuring the fuzzy algorithm concept (Wechsler, 1976), the voices weere classified into two sets, normal and pathological, with a *12%* correct classification.

Ludlow et al (1983) proposed a different index of jitter called as "deviation from linear trend" (DLT) based on the same rationale as RAP in order to minimize the slow systematic changes in frequency over many cycles. However, this technique differs from RAP in terms of establishing the trendline. In order to establish trendline, the pitch periods of two cycles away from the cycle in question in both the directions are averaged and the difference of this period from the average is calculated for all cycles except the four cycle at both the extremities (2 each) of the vowel sample. Finally, the average of all these difference data is found which is termed as the mean duration from linear trend (DLT).

However, the recent trend in establishing the trendline is to consider the period of the cycle under question also for averaging i.e., to say the alternate cycles are averaged. The mean DLT is computed over each block of 50 cycles.

DLT might not detect perturbation caused by a short cycle regularly alternating with a long one, as it occurs in pulse register (Cavallo et al, 1984; Hollien et al, 1977; Moore and Von Loden, 1958; Timeke et al , 1959; Wendahl, 1963), Lud low (1981) proposed a diplophonics ratio which is sensitive to such alternating changes. This can be obtaind after division of mean DLT by mean Jitter in millisecond. The same ratio can be converted into percentage by multiplying by 100.

Ludlow et al (1983) established an overall mean DLT value of 28.43 for 17 normal of both sexes.

The majority of the acoustic studies are done taking Jitter measurements only because of its superiority over other acoustic measures. This should not be taken to mean that Jitter can be used as the sole diagnostic criterion or that it accounts for all of what the listener percieves in the disordered voice. Far from it, factors such as shimmer and spectral noise also account for a great deal, perhaps, most, of what is heard as abnormality.

SHIMMER

Ther cycle to cyle variation in amplitude that occurs when the individual attempts to sustain phonation at a constant frequency and intensity has been termed as shimmer or amplitude perturbation like Jitter measures, measurement of shimmer also refer to glottal function (Michacl and Wendahl, 1971) and series to quantify short term instability of the vocal signal i.e, shimmer is a measurement of how much a given cycle differs from the cycle that immediately follows it in terms of peak amplitude and not how much it differs from the peak amplitude of a cycle at other end of the utterance.

Usefulness of shimmer information in the discription of voice characteristics has been clearly indicated (Von Leden & Koike, 1968; Koike, 1968; Crystal et al, 1970; Kitajima & Gould, 1976), Wendanl (1966) claims that shimmer is as important as Jitter in its contribution to the preception of hoarseness, Researchers like Takahashi and Koike (1976) and Horigudi et. al (1986) found shimmer to be more important than Jitter in terms of sensitivity to laryngeal pathology, considering all these facts, Baken (1987) coulcuded that shimmer holds promise as a diagnostic tool.

Unfortunately there is a paucity of information on shimmer as compared to Jitter. This paucity of shimmer data is partly due tolack of effective instrumentation that can process a large amount of voice samples (Koike, 1969). But this is not the case after the intoduction of computer into the area. Other contributing factors may be methodological eg., the use of microphone, tape recorder for recording, the ambient nose and reverberation in the recording room and the data reduction methods might contaminate the amplitude related information in the sample securely retaining the Jitter information or affecting it minimally.

Shimmer has not been as carefully studied as Jitter. The effect on amplitude perturbation of neither Fo nor Mean amplitude has been explored for instances. Possible differences due to age or sex remain unclear. However it is anticipated that the amount of shimmer in any given voice will be dependent at least upon the modal frequency level the total frequency range and the SPL relative to each individual voice. It is suggested therefore that the shimmer be measured under the same phonatory condition as Jitter is measured. Added to this, stability of mouth to microphone distance is very important in any intesity related measurements. There are certain studies, though not very confirmative, showing that the amplitude measurement calculated from the sample obtained from the indirect pick up methods other than air microphone (eg., contact microphone) reduces the measure (Horii, 1982). Hence, until this area is probed in depth and definite results are obtained, it is best to use a high quality air microphone (Baken 1987).

For the best amplitude measurements, one must have a recording system with a good enough frequency response to assure accurate presentation of waveform peaks. This can be obtained from the tape recorders (amplitude modulated) with a variable tape speed, while recording the sample the maximum possible tape speed should be used whereas the minimum possible tape speed should be used while playing back. But this method distorts the frequency components of the signal. That is why, Baken (1987) recommends frequency modulated (FM) tape system for any recording to be subjected to shimmer analysis.

Like Jitter measures, shimmer measures too are characteristic of normals. But pathological voices have higher magnitude of shimmer.

There are a number of methods for obtaining shimmer measures they differ among them selves in either one or more of the factors enumerated while discussing Jitter measurements. These methods are developed almost similar and parallel to the methods for jitter. Hence, this has seen the same states of development in course of time as pitch perturbation and a variety of analogous calculation methods have been enclosed including directional shimmer (Rabbien, 1981) and methods involving amplitude differences from a moving average (Danis, 1981; Kitajima & Gould, 1976; Takahashi, & Koike 1976). In most studies, measurements of either peak or peak to peak amplitudes havebeen used but in a few cases cycle to cycle differences in RMS intensity have been calculated (Kempster, 1984; Kempster & Kistler, 1984; Robbins, 1981).

Each method has its merits and limitations.

Given an adequate record, the shimmer-measurements are done in very much the same way as Jitter measurments.

The simplest calculation method that can be used to quantify amplitude perturbation is to find an absolute measure by averaging absolute differences in the peak amplitudes between adjacent pitch cycles. This can be expressed in terms of millivolts or millimetres. But this tends to be proportional to the absolute amplitude. Hence a correction is required to make this measure free from absolute amplitude which makes it necessary to divide this measure by mean peak amplitude of these cycles. This ratio is analogous to Jitter ratio or Jitter factor. This ratio can be converted into percentage by multiplying it by 100 which is called as percent shimmer. Natraja & Sanitri (1990) reported that the percent shimmer of *3%* can be considered normal and above 3% is abnormal.

The same ratio can be converted into logarithmic scale which is termed as "Shimmer in db".

Kitajima *&* Gould (1976) used this method to study 42 normal males and females and reported that average shimmer in normal phonation is of the order of 0.1 dB for the nowel \a\, with a critical value of 0.19 dB. The data ranged from 0.04 dB to 0.21 dB for normals. They also studied 25 subjects of vocal polyps who produced a result ranging from 0.08 dB to 3.23 dB for \a\ vowel.

Horii (1980) also used the same method and calculated an overall average shimmer of 0.39 dB with a critical value of 0.98 dB for the sustained vowel phonations of \a\, \i\ & \u\ for 31 normal males of age range 18-38 years. The individual shimmer values for these vowels were 0.47 dB, 0.37 dB and 0.33 dB respectvely. Later, in another study with 12 adult males age ranging from 24-30 years, Horii (1982) found shimmer value as 0.62 dB, 0.48 dB and 0.34 dB for \a\, \i\ and \u\ vowels respectively with an average fundamental frequency of 104.3 Hz.

Heiberger and Horii (1982) tested 20 normal adult males with a mean age of 27.5 years and reported a mean shimmer value of 0.17 dB.

Soreuson & Horii (1983) calculated the shimmer values for 20 normal females age ranging from 25-49 years and reported an overall shimmer of 0.25 dB with an individual shimmer value for \a\, \i\ & \u\ vowels as 0.33 dB, o.23 dB and 0.19 dB respectively. Zyski, Bull, Mcdonald & Johns (1984) examined 20 normals and 52 subjects with laryngeal pathology and reported a shimmer values ranging from 0.89 dB to 41.84 dB in normals and 2.14 dB to 1,444.15 dB in pathological cases. Kane and Wellen (1985) using 10 children (6-11 years) with vocal nodules found shimmer value of 0.0151 dB to 0.0911 dB with a mean of 0.0577 dB. Sirdhara (1986) studied 30 young normal males and females using \a\, \i\ & \u\ vowels. He reported the following values of men shimmer in dB.

Table 2.3

Sex	\a\	\i\	\u\
Males	0.033	0.066	0.15
Female	0.7	0.37	0.44.

Hecker & Kruel (1971), along with the directional perturbation factor for pitch, applied the same technique to compute the directional perturbation factor for amplitude also. DPF for amplitude (Amplitude DPF) is defined as the percentage of peak amplitude differences between adjacent cycles which differred in algebric sign. So, the measures tallies the number of times that the amplitude changes between two successive waves shifts direction. Sorecison & Horii (1984) have studied the amplitude DPF in 40 normal males and females (20 each) with j agefranging from 25-49 years using the three vowels \a\, \i\ & \u\. They reported the values as 59.47% , 61.13% and 58.91% for males and 63.13%, 61.71% and 59.76% for female respectively.

Takahashi and Koike (1976) and koike et al (1977) has developed a measure termed as amplitude perturbation quotient (APQ) which is analogous to the relative average perturbation (RAP) originally devised by Koike (1973). APQ is defenid as the variation in signal amplitude measured at the fundamental period divided by the mean amplitude. APQ minimizes the effects of slow and smooth amplitude drift like RAP does for a similar period changes. Kitajima and Gould (1976) proposed using deviation from a least square trend line to eliminate the long term changes in vocal intensity, but their method was cumbersome. As opposed to the Kitajima and Gould (1976). APQ provides an easier way of establishing the trendline using eleven point average for smoothing.

Takahashi and Koike (1976) reported mean APQ values of 40.3x10 and 32.9x10 for males and females respectively for unsustained \a\ vowel.

Deal and Emanuel (1978) proposed another measure of shimmer called as amplitude variability index (AVI) analogous to their own jitter indes, pitch variability index (PVI). It is not an average of the cycle-to-cycle amplitude variation, but rather it represents the average degree of variation from the mean peak amplitude of the sample. It is unique among perturbation measures in this respect, and it is clearly not equivalent to the other amplitude variability indices that have been proposed.

Like PVI, AVI also is based on the statistical technique of coefficient of variation and is defined as the mean of the squares of the deviations of peak amplitude divided by the square of the men peak amplitude, multiplied by 1,000.

They evaluated their index with samples of sustained vowels produced at 75 dB SPL for 7 seconds by normal adult males and by clinically hoarse males (20 each) and reported mean AVI of -0.0619, -0.1330, and -0.1287 for \a\, \i\ and \u\ vowels respectively for normal males, and 0.2163, 0.5706, and 0.4142 respectively for the same vowels for clinically hoarse males.

Venkatesh, Sathya & Jenny (1992) reported the normative data on pitch and amplitude perturbation measurements in normals and discriminant funciton analysis of pitch and amplitude perturbation measurements in disphonics. Raghunath, Baldva and Venkatesh (1992) reported on quantitative measurement of degree of hoarseness using jitter and shimmer.

Thus the review proves that jitter and shimmer are powerful tools for the differential diagnosis of various voice pathologies. Several factors have been found to effect the values of perturbation measurements such as age, sex, vowel produced, frequency and intensity level of the phonatory sample, type of phonetary initiation and termination, duration of phonation sample and the sampling frequency used for digitization of the sample.

Wilcox (1978), Wilcox and Horri (1980) comared the jitters of sustained /a/, /i/, and /u/ produced by young and older adult males. The results showed a significantly greater amount of jitter in sustained phonations of the older adults (0.75%), than was seen in the younger subjects (0.57%). This was attributed to the reduced sensory contributions from the laryngeal mechanoreceptors.

Linville (1988) has reported that the jitter values were larger in old women than in young children. They also found that the intra subject variability within one recording session was high for some female speakers.

Higgins and Saxman (1989) reported higher values of frequency perturbation in males than females. Gender difference may exist not only in magnitude but also in the variability of frequency perturbation.

Sorenson and Horii, (1983) reported that normal female speakers have more jitter than normal male speakers. This result is contradicting the findings of Higgins and Saxman, (1989).

Robert and Baken, (1984) reported higher jitter values in males than females. They attributed this difference to fundamental frequency. When the fundamental frequency increase the percentage of jitter values decreases.

Zemlin, (1962) has reported a significantly greater jitter for /a/ than /i/, and /u/ had lowest value. This result is supported by the studies of Wilcox (1978) and Linville and Korabic (1987).

Johnson and Michel, (1969) reported greater jitter value for high vowels than low vowels in 12 English vowels.

Nilcox and Horii (1980) reported that /u/ was associated with significantly smaller jitter (O.55% than /a/ and /i/ 0.68% and 0.69% respectively).

Sorenson and Horii (1983), studied the vocal jitter during sustained phonation of /a/, /i/ and /u/ vowels. The result showed that jitter values were low for /a/ with 0.71% high for /i/ with 0.96% and intermediate for /u/ with 0.86%.

Sorenson and Horii, (1984) reported that directional jitter factor values were highest for /u/ and /a/ had lowest and /i/ was intermediate.

Heiberger & Horii, (1980) and Horii, (1982) reported that there is no significant difference between the eight English vowels.

Linville and Korabic, (1987) have found that intraspeaker variability tend to be greater on the low vowel /a/, with less variability on high vowels /i/ and /u/. The factors which are considered in this study are the sample duration and temporal resolution required for these perturbation measurements.

Sample Duration:-

This is decided based on the concept of stability of any statistics above a cut off size of sample. One can have a representative sample size above this cut off and can generalize the findings, but the smaller sample size does not give faithful results. Sample duration in acoustic studies depends upon the optimum size of the window (token) and the optimum number of tokens.

(a) Size of Window:- A windo of 20-30 cycles within a given token of normal steady vowel phonation is suggested by Titze et al (1987) for jitter and shimmer analysis. Deem et al (1989) advised to use at least 40 cycles in a token when measuring jitter in normal speakers. However, it is uncertain to say that the same window size sill be suitable for pathological cases.

(b) Type of window:- There are different types of window with their relative advantages and disadvantages. The simplest is the rectangular window but this produces significant demarcation errors making interpolation necessary for good performance.

Hence, the researchers have tried different ways of tapering the window. A tapered window function will provide additional control of spectral leakage. This may be advatageous in HNR estimation for reducing sensitivity to errors in demarcation of data segments. Tapering caused a large reduction inthe sensitivity to HNR to pertubation level.

(c) Number of Tokens:- A single token of a steady vowel is insufficient to establish a reliable acoustic measure. Hence multiple tokens of an utterance are necessary to obtain a stable mean for rerturbation measures (Titze et al, 1987).

TEMPORAL RESOLUTION:

The number of times an analog acoustic waveform is sampled in a second during digitization process is termed as temporal resolution. This is also referred to as the sampling frequency or sampling rate and is commonly expressed in the unit of cycles per second (cps) or Hertz (Hz). Because of the need of high resolution, it is also expressed in the unit of Kilohertz (KHz). Some people prefer to express it in samples per cycle and some others in millisecond (msec).

The digitization process requires that the incoming analog electrical voltage information be converted to numerical form at a very rapid rate. Usually this process results in a sampling frequency of morethan 10,000 Hz for frequency extraction whereas for perturbation analysis, a sampling frequency of as high as 1,00,000Hz may be required. But in practice, slower rates can be used if the data are then submitted to a mathematical interpolation. (Karnell, 1991).

The most common method of sampling is to observe and store the instantaneous level of the waveform at evenly spaced points in time. If it is known that the signal is "bandlimited" i.e., that the spectrum of the signal has no frequency components above some frequency (f max) then it can be shown that sampling the signal at a frequency greater than 2xf max will provide a unique representation. This frequency is called the Nyquist frequency.

If the sampling frequency is below the Nyquist frequency, then a phenomenon called "aliasing" accurs. High frequency components becomes indistinguishable from some of the lower frequency components. The standard method for preventing aliasing is to filter the signal prior to sampling in order to attenuate the high frequency components.

Temporal resolution is a critical factor affecting all the acoustic measurements but especially the accuracy of jitter measurement is limited by the temporal resolution which becomes more important when peak-to-peak measures are the basis of

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acoustic analysis. Horii (1979) advocated for higher rates of sampling for perturbation studies although the majority of researchers have used a sampling rate of 0.05 mse. (Zyski et al, 1984). Lower sampling rate generates sampling noise which contaminates the original signal.

A minimum of 500 samples per cycle are needed to minimize the contaminating sampling noise without interpolation between sample. With interpolation, however, fewer than 100 samples per cycle can resolve jitter down to 0.1% (Titze et al , 1987).

Cox, Ito & Morrison (1989) reported that increasing the sampling frequency from 10 KHz to 20KHz had little effect on DFT based HNR estimates with all differences being 0.6 dB in perturbed data. However the same in perturbation free data brought HNR from 21.9 dB to 41.2 dB for \i\ vowel and from 29.4 dB to 49.0 dB for \a\ vowel suggesting that over sampling brings a significant improvement in perturbation free data.

Interpolation:- Interpolation is a mathematical process which calculates probability estimates of numbers betwen the actual numbers obtained from the digital sampling of the analog signal. As, not many researchers have access to costly hardware having a high sampling rate as several hundred KHz, the next best strategy to improve the temporal resolution of analog to digital systems would be interpolation techniques. Interpolation provides an obvious advantage for the estimation of jitter, particularly if relatively low sample rate is used (100 KHz) interpolation provides little advantage (Deem, Manning, Knack & Matesich, 1989). Titze et al (1987) recommends to use interpolation between samples in the extraction of normal vocal jitter with less than 500 samples per sec.

Deem, Manning, Knack & Matesich (1989) reported that (a) the use of interpolation with the peak picking extraction procedures had little effect on the jitter values.

The extraction procedures using interpolation with zero crossing yielded the lowest jitter values.

There are different types of interpolation. The most common is the linear interpolation. However, because of acoustic waveform cannot be considered as linear, Markel and bray (1976) used parabolic peak interpolation for reducing the effects of sampling error in shimmer analysis.

Cox Ito & Morrison (1986) used interpolation of a cross-correlation function to optimize the pitch period markers in order to reduce quantization and demarcation errors. This method provides a means forobtaining high resolution in pitch period markers without using high sampling frequencies. They demonstrated its use in the analysis of jitter and HNR estimation for synthetic and real data with low cost hardware system.

AMPLITUDE RESOLUTION:- This is commonly known as bit resolution which gives the resolution of a system along the ordinatewhere the amplitude of the acoustic waveform is represented. This is usually expressed in terms of number of bits which can easily be converted into relatively simpler unit of amplituderesolution i.e., the number of samples per unit amplitude. For example, a two bit system could assign all incoming information into one of 4 (2) possible values, a four bit system into 16 (2) possible values and so forth. However the bit resolution of a system does not guarantee that all available bits will be used. To take a full advantage of the amplitude resolutionof a system, the input signal must be amplified so that its amplitude approximates the full scale limit of the A\D converter.

In addition to an adequately fast sampling rate, adequate bit resolution is also an important factor for perturbation measurements. Particularly for shimmer measurement, the hgiher the bit resolution, the better, i.e., to say that the accurracy of shimmer measurement is limited by the bit resolution.

Lower bit resolution produces the bit noise contaminating the original analog signal. A minimum of nine bits of resolution are needed to minimise the contaminating bit noise without interpolation (Titze et al 1987).

Paul M. (1987) was the first one to have talked about low sampling frequency of 8.3 KHz while studying least mean square measures of voice perturbation. Sample duration taken was 100 msces. He suggested that it is possible to measure the low levels of jitter characteristics of the normal voice using a much lower signal sampling rate than previously reported. The use of a lower sampling rate is a major improvement on several accounts. The lower sampling rateis more readily achieved using widely available low cost desk top computers and low cost A\D hardware. In addition, the low sampling rate reduces the storage requirements for the digitized signals. This allows for longer duration digital recording to be made using desk top computers which are typically limited in their storage capacity. It also decreases the cost of archiable storage of digital recordings made for this type of analysis.

The present study is aimed at studying the effect of duration of voice sample and temporal resolution of perturpation measurements. The sample durations of 0.5 secs, 1 sec, 2 sec and 3 sees and temporal resolution of 8,000 Hz ana 16,000 Hz are compared for their efficacy in the measurement of frequency and amplitude perturbations.

CHAPTER - III

METHODOLOGY

METHODOLOGY

Experiment - 1 :

Subjects:- Thirty normal adult males and thirty adult females ranging from 19 to 35 years, served as subjects. None of the subjects had any voice problem and all were free from cold or sinces problem at the time of the experiment. Seven male dysphonics and three female dysphonics with age range 30 to 55 years constituted the pathological group. Laryngological examination of the dysphonics was performed using fibreoptic laryngoscope by a laryngologist, and made definitive diagnosis of Laryngeal disorder.

MATERIAL FOR VOICE SAMPLE:

The subjects were instructed to phonate /a/, /i/ and /u/ within 55-60 dB SPL for 35 seconds. It was emphasized that the subject keep his voice as steady as possible at a comfortable and constant pitch and intensity. Three trials of phonation of each vowel, that is, totally nine phonations of 5 seconds each were taken for the measurement of frequency and intensity perturbation.

Table No.3.1 Showing the distribution of subjects in experiment No.1 .

	Normal	Dysphonics
Males	30	7
Females	30	3

RECORDING

The subjects were seated comfortably and the voice source recording was done using the Electroglottography (EGG-Kay Laryngograph 80138). The electrodes of the EGG wave placed on the thyroid laminae of the subjects and they were asked to phonate vowels /a/, /i/ and /u/ for 5 seconds. Three trials of phonation of each vowel was obtained. Prior instructions were given to the subjects as not to move their head or neck during phonation. The Kay Laryngograph was used to obtain the EGG waveform during phonation. Digitization of the EGG waveforms was done with a sampling frequency of 16 KHz, using a 12 bit ADC card. The digitized EGG wave forms of phonation were stored in the secondary memory of a PC-At 386 and were used for the perturbation analysis at various sample durations of 0.5 sec, 1sec, 2secs, and 3 secs.

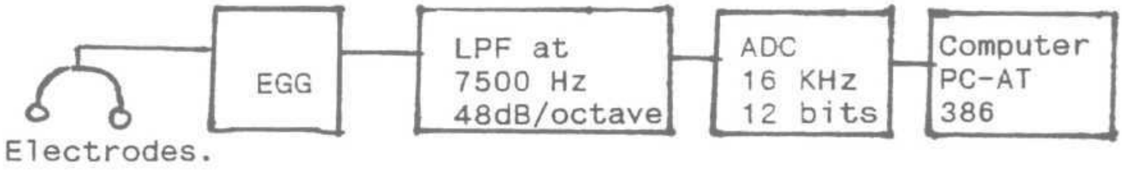


Figure 3.1 Block diagram showing the instrumental set-up

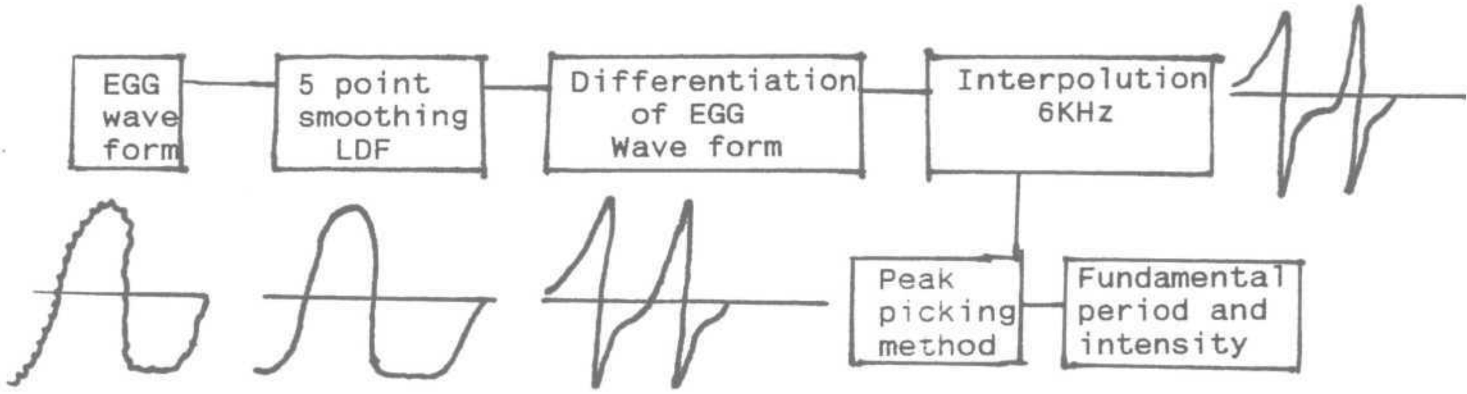


Figure 3.2 Figure showing the extraction of fundamental frequency

PERTURBATION ANALYSIS:- This analysis was carried out with the help of a computer programme called "JTSHMX" developed by voice and Speech Systems, Bangalore. Sample durations of middle 0.5 sec, 1 sec, 2 sec and 3 sec were used for extraction of fundamental frequency and Pitch & ampltitude perturbation values using digital PC-AT 386. The EGG waveforms were initially passed through a low pass digital filter having a cut off frequency of 500Hz. The filtered waveforms were then differentiated and then interpolated to 64 KHz. Peak picking method was used to extract cycle to cycle fundamental period from the EGG waveforms.

The following algorithms were used to obtain frequency and intensity perturbation values form the fundamental period with help of digital computer PC-AT-386.

Fundamental Frequency pertugbations:

1) Jitter Ratio (JR) =
(Horii, 1979)

$$\frac{1/(n-1)\left[\sum_{i=1}^{n-1} \left| P_i - P_i + 1 \right|\right]}{1/n \sum_{i=1}^{n} P_i} \times 1000$$

2) Directional Perturbation Quotient (DPQ)=(Hecker and Krevl, 1971). It is defined as the percentage of the total number of differences in pitch period for which there is a change in algebric sign.

Amplitude Perturbation Measurements:

1) Shimmer (In dB) =
(Horii, 1980)

$$\sum_{i=1}^{n-1} \cdot \frac{\left| 20 \log \left(A_i / A_i + 1 \right) \right|}{n-1}$$

2) Directional pertorbation Quotient for Amplitude (DPQ-A)

(Hecker and Kreul, 1971):- It is defined as the percentage of the total number of differences in amplitude for which there is a change in algebraic sign.

EXPERMENT - 2:

Subjects:- Five normal adult males and five normal adult females ranging in age from 18 to 25 years served as subjects. None of the subjects had any voice problem and all were free from cold or sinus problem at the time of the experiment.

Material for voice sample was the same as the experiment 1.

Recording was done in a similar manner as in experiment 1 using the Kay laryngograph. Digitization of the EGG waveform was done with a sampling frequency of 16 KHz using a 12 bit ADC card. The digitized EGG wave forms of phonation were stored in a PC-AT 386 and were used for the perturbation analysis for 3 secs sample duration.

The stored data was copied into another file and then digitally low pass filtered at 3500Hz and down sampled to a sampling frequency of 8,000 Hz using a computer programme 'DOWNS' developed by Voice and Speech Systems, Bangalore. These digitized data of 16 KHz & 8 KHz sampling frequency were used for perturbation analysis for a sample duration of 3 secs.

PERTURBATION ANALYSIS:

The analysis was carried out in the same manner as in experiment 1 for both sampling frequencies 16,000 Hz and 8,000 Hz. The same algorithms of frequency and intensity perturbation were used as in experiment - 1.

STATISTICAL ANALYSIS :

The obtained pitch and amplitude perturbation data were further statistically treated using the following statistical procedures.

a) Descriptive statistics

b) T-test

c) Analysis of variance (ANOVA)

CHAPTER - IV

RESULTS AND DISCUSSION

TABLE 4.1 Table showing mean and standard deviation in Fundamental Frequency of Vowels /a/, /1/ and /u/ for normals and dysphonics across different sample durations (0.5, 1,2 and 3 seconds)

Subjects	Voice sample	durations			
		3 sec	2 sec	1 sec	0.5 sec
Normal males	/a/	120.03 (15.0368)	119.96 (15.0447)	119.74 (15.091)	119.68 (15.03)
	/i/	127.04 (16.0838)	127.13 (16.1389)	127.31 (16.2371)	127.34 (16.3467)
	/u/	129.28 (16.5968)	129.78 (16.632)	129.99 (16.8953)	130.38 (17.1418)
Normal females	/a/	230.30 (19.0713)	230.36 (18.9660)	230.27 (18.7397	230.09 (18.6236)
	/i/	238.41 (20.93)	238.62 (20.8134)	238.61 (20.74)	238.51 (20.6535)
	/u/	243.01 (24.0944)	243.72 (23.8056)	243.14 (23.0283)	243.73 (23.7815)
Dysponics	/a/	176.81 (50.6686)	174.9 (50.6769)	174.37 (51.9043)	173.56 (50.9638)
	/i/	179.11 (47.1647)	174.17 (47.0186)	178.21 (44.8739)	179.37 (44.8588)
	/u/	177.68 (47.0653)	177.7553 (43.73445)	177.72 (42.6394)	177.9 (42.4838)

TABLE 4.2. Table showing mean and standard deviation in Jitter Ratio of Vowels /a/, /i/ and /u/ for normals and dysphonics across different sample durations (0.5, 1,2 and 3 seconds)

Subjects durations	Voice sample	3 sec	2 sec	1 sec	0.5 sec
Normal males	/a/	12.0763 (8.5876)	11.7695 (5.6595)	11.0079 (5.1785)	8.4592 (5.0794)
	/i/	8.3257 (2.8114)	10.2086 (4.0155)	10.0491 (4.8138)	6.1451 (3.171)
	/u/	9.1466 (2.9211)	10.332 (3.6568)	10.2529 (3.7403)	7.0044 (4.2471)
Normal females	/a/	8.8885 (3.1545)	9.1918 (2.5728)	0.1094 (3.0689)	7.1681 (3.2436)
	/i/	8.2077 (3.6959)	8.4975 (3.7453)	8.0962 (3.3431)	6.6904 (3.3197)
	/u/	8.4271 (3.0291)	9.074 (3.187)	8.34 (3.3351)	6.5632 (3.0607)
Dysponics	/a/	208.9588 (209.1557)	160.1128 (181.1439)	146.9129 (189.141)	136.01 (174.2814)
	/i/	156.8109 (213.317)	104.0758 (188.0314)	103.3641 (189.141)	97.9099 (206.2835)
	/u/	139.6754 (182.4711)	70.70321 (8.6387)	95.3322 (158.3608)	92.7307 (161.7146)

TABLE 4.3. Table showing mean and standard deviation in Directional Perturbation Quotient (DPQ) of Vowels /a/, /i/ and /u/ for nomals and dysphonics across different sample durations (0.5, 1,2 and 3 seconds)

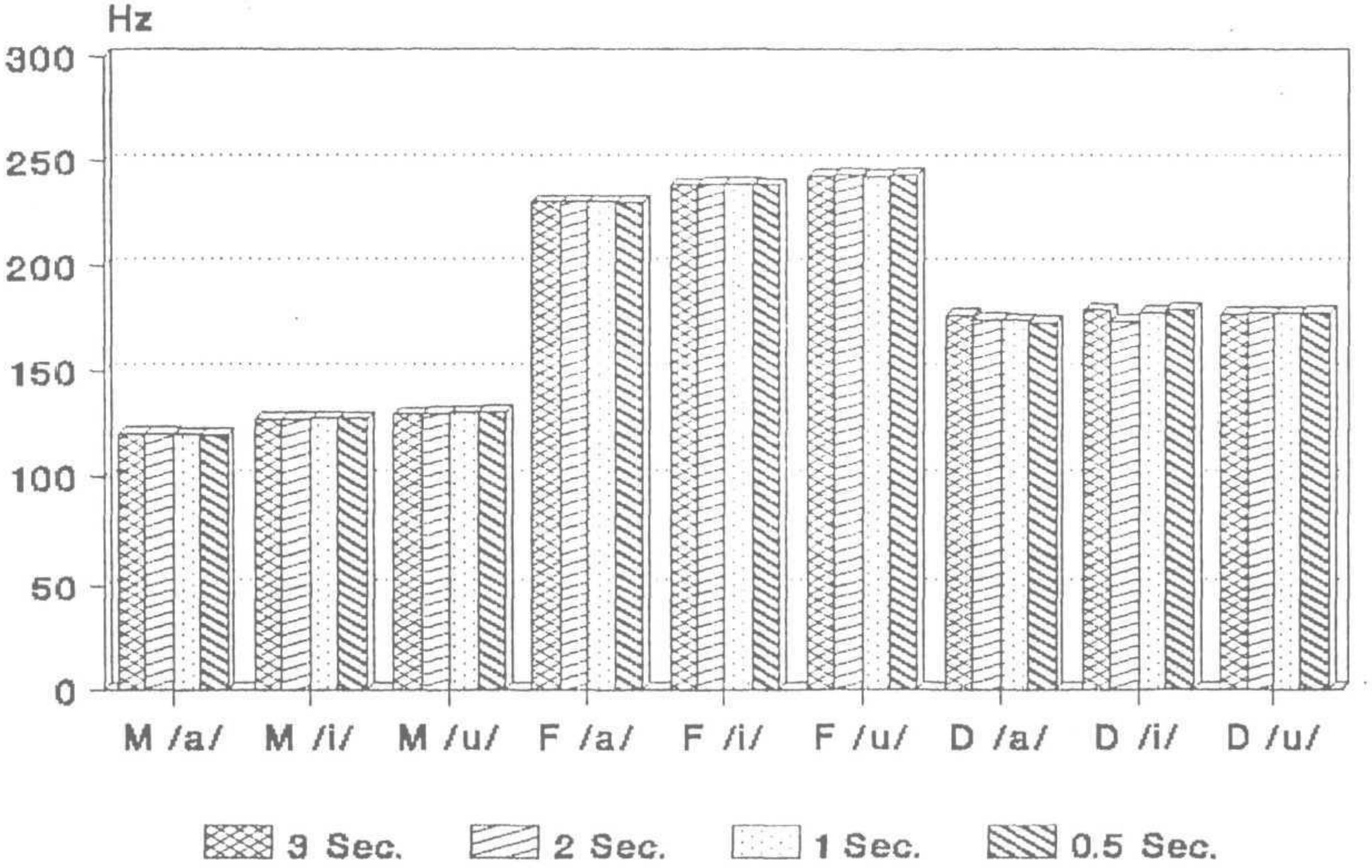
Sub jects	dura- tions	Voice sample	3 sec	2 sec	1 sec	0.5 sec
Normal males		/a/	59.9897 (6.388)	60.3 (6.671)	60.1204 (7.5391)	60.2492 (9.34)
		/i/	57.5802 (6.2949)	57.8655 (6.6063)	57.6241 (7.2802)	56.8623 (7.7363)
		/u/	57.3888 (5.852)	57.1248 (6.257)	56.2499 (6.7791)	56.1135 (8.231)
Normal females		/a/	59.9929 (5.6594)	59.2964 (5.6894)	58.7326 (5.951)	58.3323 (7.069)
		/i/	57.6093 (8.8818)	57.1269 (9.0001)	56.1172 (8.2316)	56.3446 (9.2663)
		/u/	59.1385 (9.1776)	58.6656 (8.8987)	57.3472 (8.2356)	58.053 (10.7134)
Dysponics		/a/	72.2557 (9.0003)	70.70312 (8.6387)	67.6353 (13.8373)	71.1699 (8.9243)
		/i/	72.7753 (10.9437)	69.6092 (11.0787)	68.9921 (10.711)	68.6504 (10.7586)
		/u/	74.1055 (11.8851)	70.7032 (11.7511)	69.5644 (12.1074)	70.3498 (12.2487)

TABLE 4.-4. Table showing mean and standard deviation in Shimmer in (dB) of Vowels /a/, /i/ and /u/ for nomals and dysphonics across different sample durations (0.5, 1,2 and 3 seconds)

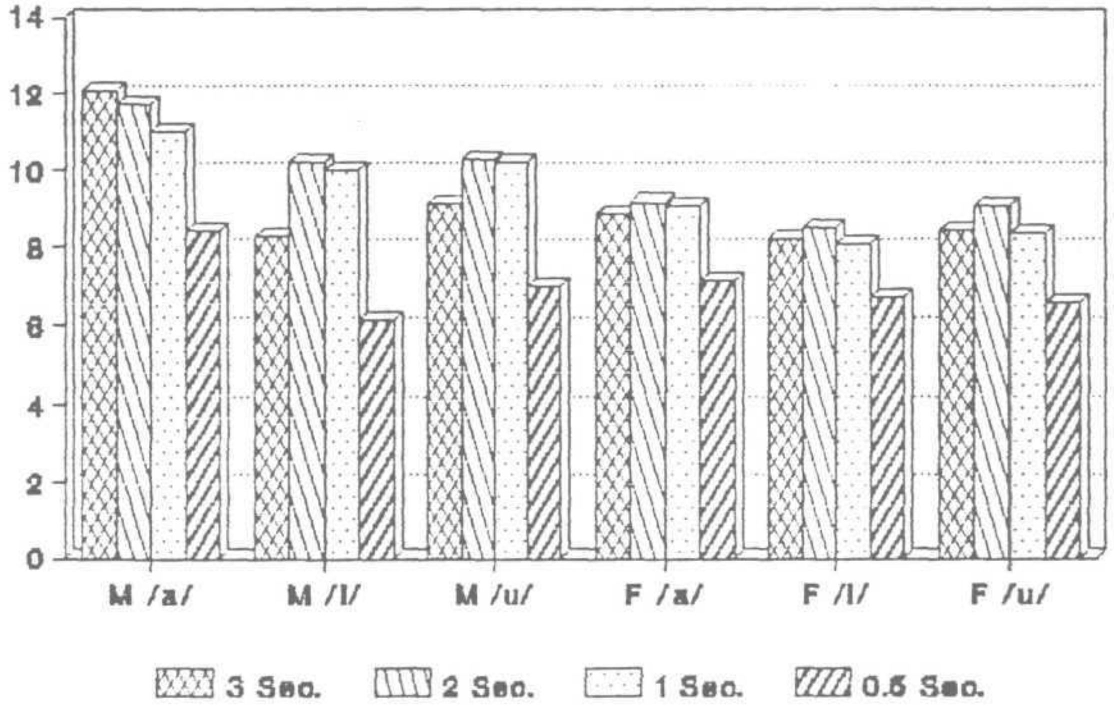
Sub jects	dura- tions	Voice sample	3 sec	2 sec	1 sec	0.5 sec
Normal males		/a/	0.328 (0.3806)	0.3063 (0.1709)	0.3074 (0.1808)	0.2989 (0.2238)
		/i/	0.2197 (0.154)	0.2251 (0.1416)	0.2348 (0.168)	0.2494 (0.2163)
		/u/	0.2485 (0.2599)	0.2413 (0.1544)	0.2607 (0.2043)	0.241 (0.2056)
Normal females		/a/	0.29259 (0.1666)	0.2946 (0.1806)	0.2865 (0.1907)	0.2684 (0.1976)
		/i/	0.2276 (0.1428)	0.2208 (0.1333)	0.2184 (0.1307)	0.221 (0.1497)
		/u/	0.1991 (0.1148)	0.1959 (0.1168)	0.2061 (0.1162)	0.1901 (0.1148)
Dysponics		/a/	7.4034 (14.0641)	3.8976 (4.7657)	4.0169 (4.6059)	3.9762 (4.74)
		/i/	4.503 (7.80722)	3.4955 (6.846)	3.3989 (6.6293)	3.4219 (7.04)
		/u/	4.4849 (8.0722)	3.5831 (7.0149)	3.3663 (6.5932)	3.3976 (6.7387)

TABLE 4.5. Table showing mean and standard deviation in Directional Perturbation Quotient for Amplitude (DPQ-A) of Vowels /a/, /i/ and /u/ for nomals and dysphonics across different sample durations (0.5, 1,2 and 3 seconds)

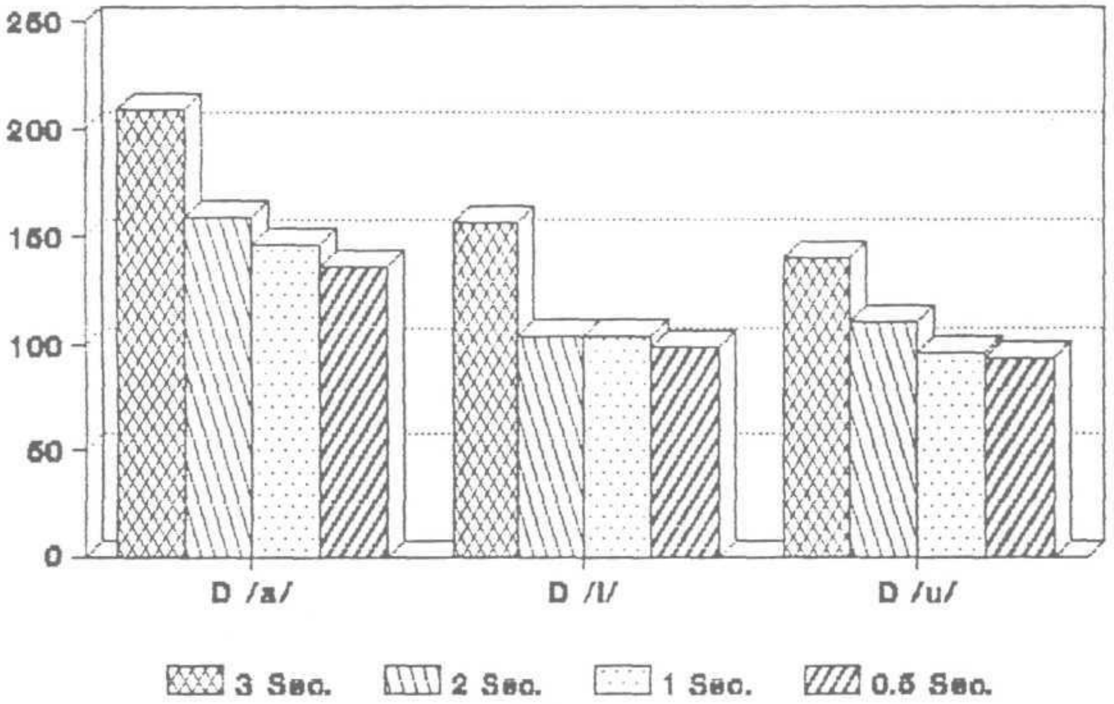
Subjects	durations	Voice sample	3 sec	2 sec	1 sec	0.5 sec
Normal males		/a/	60.2752 (6.2974)	59.9346 (6.5093)	60.3023 (6.8562)	60.6333 (8.6744)
		/i/	59.444 (5.8005)	59.2321 (6.2807)	60.1712 (7.4524)	605581 (9.0106)
		/u/	60.7122 (4.8714)	60.726 (5.6173)	60.2786 (9.1611)	59.69 (8.4285)
Normal females		/a/	65.0418 (2.4094)	65.0414 (2.7642)	64.3122 (3.2967)	64.434 (4.3131)
		/i/	66.1453 (3.0423)	66.1628 (3.6044)	65.6455 (4.1423)	65.2861 (4.2778)
		/u/	66.5462 (3.5462)	66.9959 (4.8115)	66.5452 (4.8981)	66.9793 (5.433)
Dysponics		/a/	69.6021 (11.1346)	70.8321 (10.2477)	70.6402 (11.1595)	72.1678 (11.6249)
		/i/	70.4318 (12.1298)	67.9518 (11.2703)	67.2621 (11.458)	66.842 (11.3935)
		/u/	71.5292 (12.5013)	68.7086 (11.4009)	68.7347 (11.448)	68.8867 (11.8942)



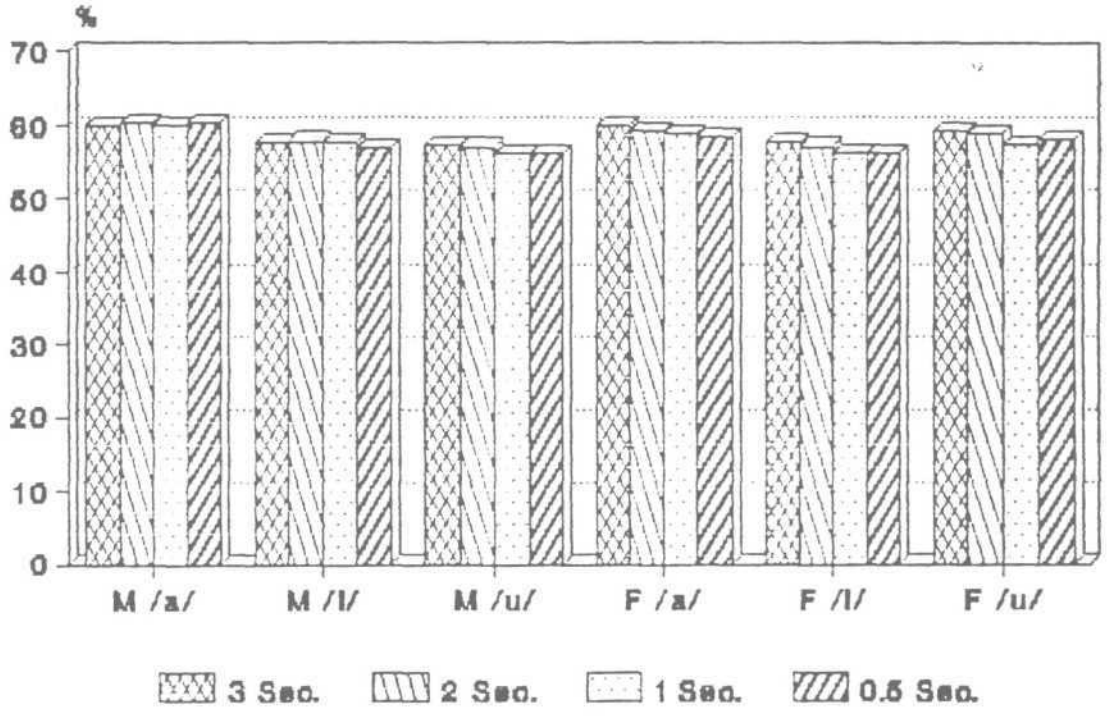
Graph 4.1 Fundamental freqeuncy (Fo) of males,females and Dysphonics for the vowels /a/, /i/ and /u/ across 3, 2, 1 and 0.5 second sample durations.



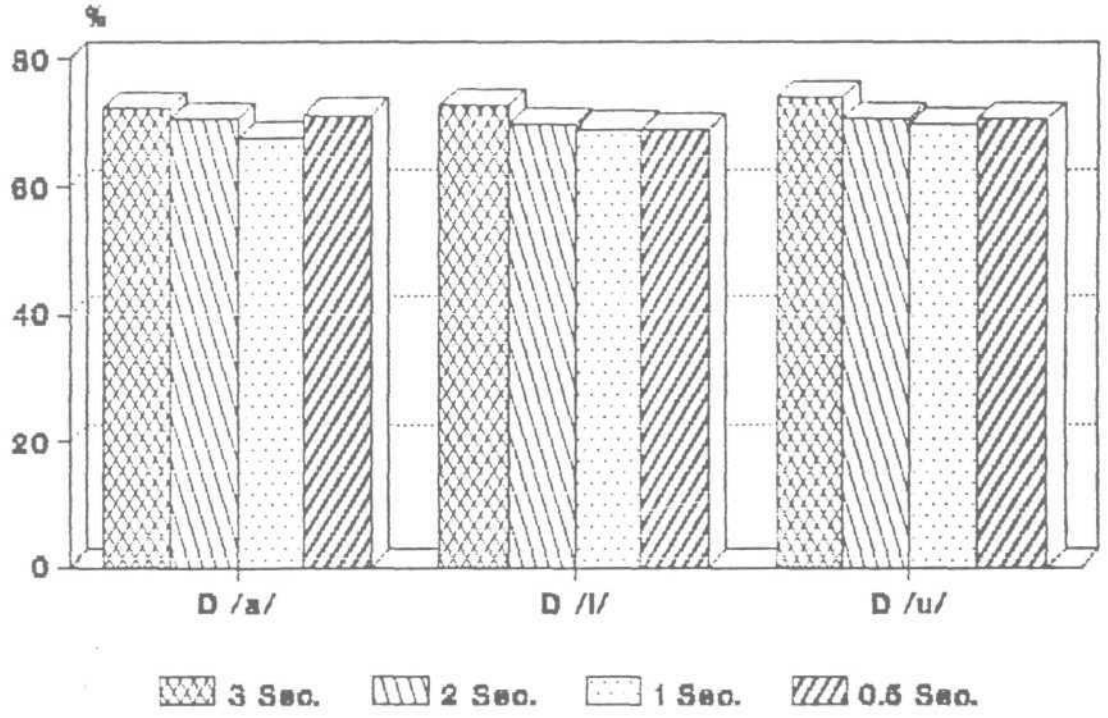
Graph 4.2 Jitter Ration (JR) of normal males and females for vowels /a/,/i/ and /u/ across 3, 2, 1, and 0.5 second sample durations.



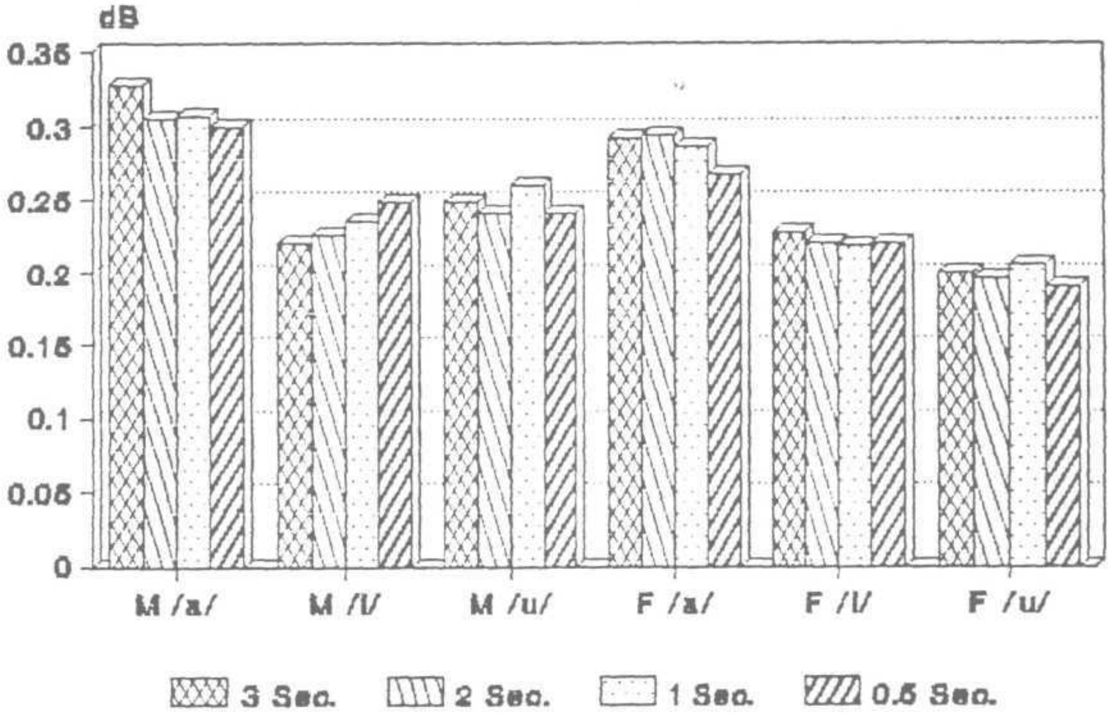
Graph 4.3 Jitter Ratio (JR) of Dysphonics for vowels /a/, /i/ and /u/ across 3, 2, 1, and 0.5 seconds sample durations.



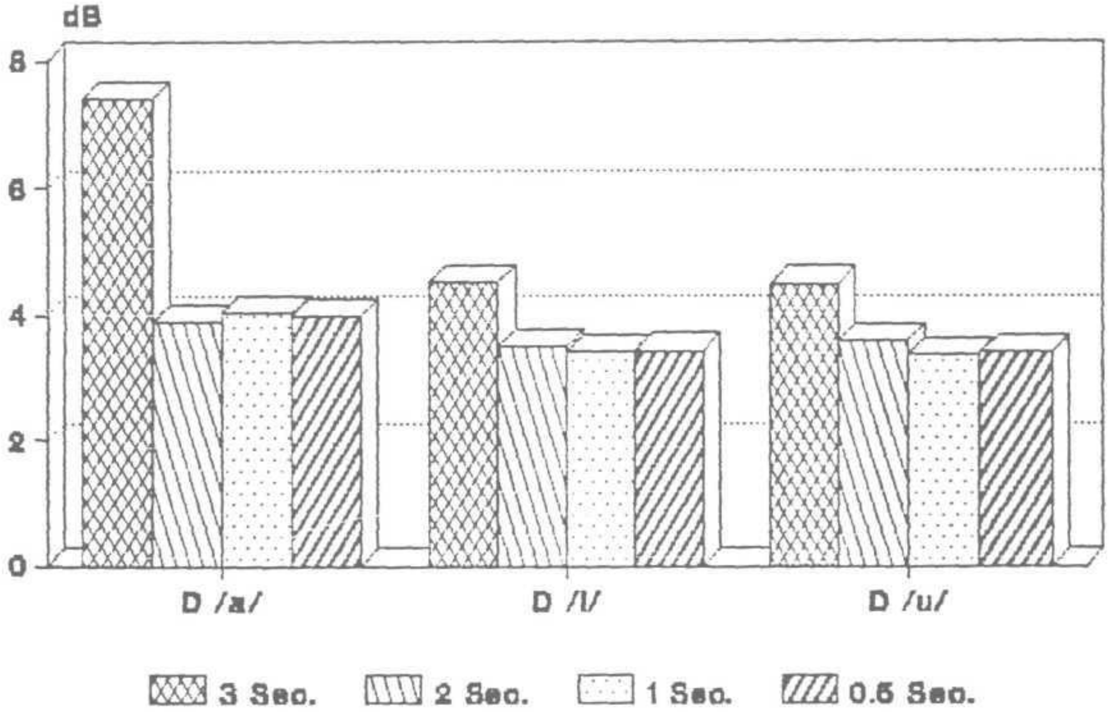
Graph 4.4 Directional Perturbation Quotient (DPQ) of males and females for vowels /a/, /i/ and /u/ across 3, 2, 1 and 0.5 second sample durations.



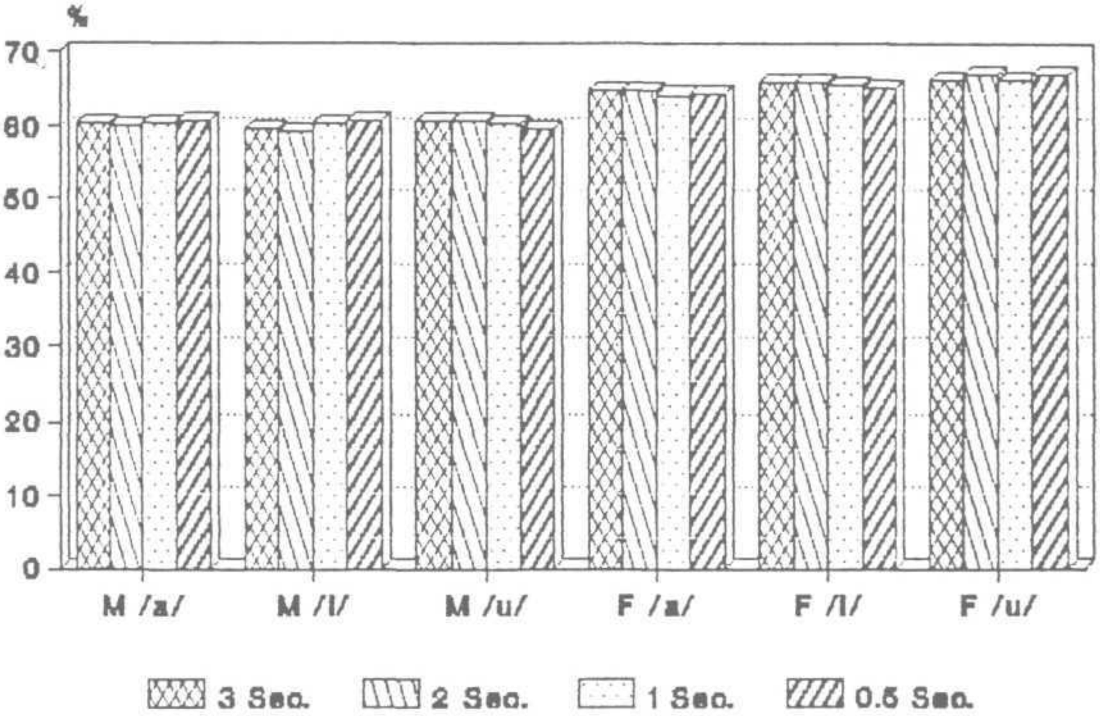
Graph 4.5 Directional Perturbation Quotient (DPQ) of Dysphonics for vowels /a/, /i/ and /u/ across 3, 2, 1 and 0.5 second sample durations.



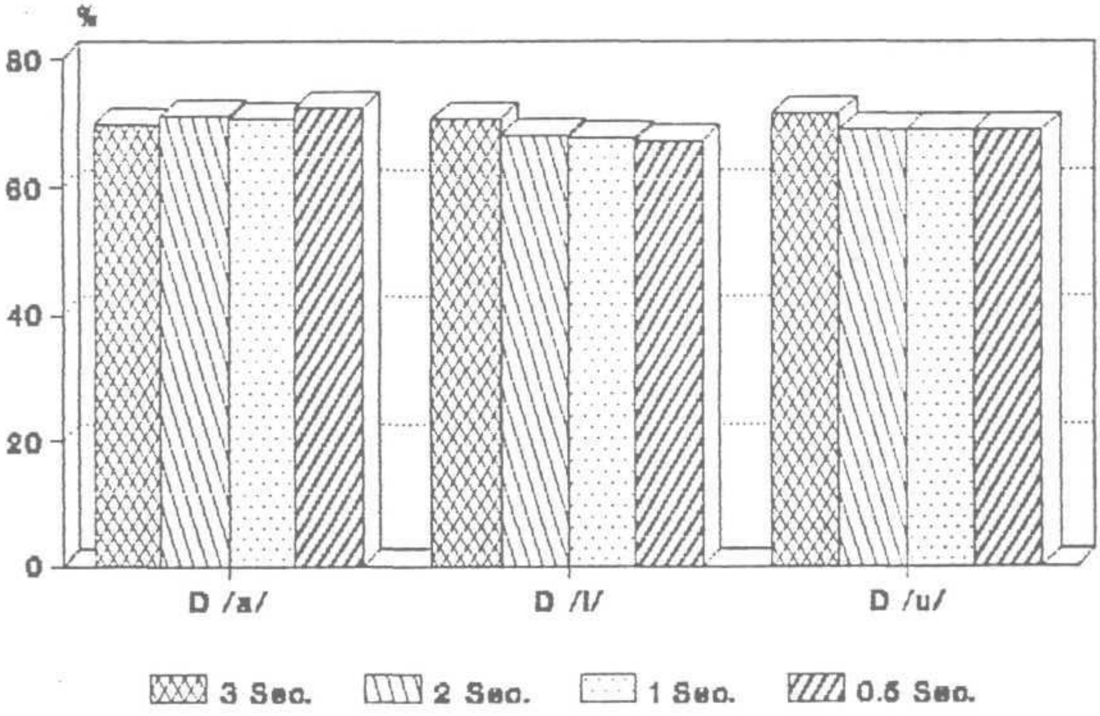
Graph 4.6 Shimmer (dB) of normal males and females for the vowels /a/, /i/ and /u/ across 3, 2, 1 and 0.5 second sample durations.



Graph 4.7 Shimmer (dB) of dysphonics for the vowels /a/, /i/ and /u/ across 3, 2, 1 and 0.5 second sample durations.



Graph 4.8 Directional Perturbation Quotient for amplitude (DPQ-A) of normal males and females for the vowels /a/, /i/ and /u/ across 3, 2, 1 and 0.5 second sample durations.



Graph 4.9 Directional Perturbation Quotient for amplitude (DPQ-A) of dysphonics for the vowels /a/, /i/ and /u/ across 3, 2, 1 and 0.5 second sample durations.

RESULTS & DISCUSSION

Experment-1.

The aim of experiment-1 was to evaluate the effect of sample duration on perturbation measurements. Table 4.1 to table 4.5 gives the mean and standard deviation of fundamental frequency, Jitter Ratio (JR), Directional Perturbation Quotient for Pitch (DPQ), Shimmer in (dB), Directional Perturbation Quotient for Amplitude (DPQ-A) at different sample duation. The same is depicted in the graph no. 4.1 to 4.9.

The Fo, pitch and amplitude perturbation measures were measured for the phonation of /a/, /i/ and /u/ vowels each having three trails of phonation. In an attempt to reduce the data, one way ANOVA was conducted to know the significance of difference between the means of different trails. The following Table 4.6. Provides you the F value and its probability for different sample duration with different groups of subjects.

TABLE 4.5 - Table showing F value and its probability across different sample durations (3,2,1 and 0.5 secs.) for different groups of suibjects.

Sample Duration	Normal Males F	P	Normal Females F	P	Dysphonics F	P
3 sec	0.19	0.8281	1.45	0.2404	0.02	0.9844
2 sec	0.04	0.6718	0.11	0.8953	0.05	0.9549
3 sec	2.04	0.1358	0.35	0.7074	1.00	0.381
0.5 sec	0.064	0.5301	0.23	0.7959	1.00	0.3806

By the scrutiny of above table it can be stated that there was no significant difference, at 0.05 level, between the three trials of different measures of pitch and amplitude perturbation having different sample duration. Here F value is well below 2.0 and the probability was above 0.13.

As there was no significant difference between the trials, the data of three trials were added, that made 90 samples in each group. Further, to know the significance of mean difference between males and females another one-way ANOVA was conducted and the results were tabulated below in table No. 4.7.

TABLE 4.7 : Table showing F value and its probabilty for Normal Dysphonics across various parameters (Fundamental Frequency (Fo), Jitter Ratio (JR), Directional Perturbation Quotient for Pitch (DPQ), Shimmer (dB), Directional Perturbation Quotient for Amplitude (DPQ-A)).

Parameters	Normals		Dysphonics	
	F	P	F	P
Fo	94.31	0.0000	0.01	0.9986
JR	3.18	0.0762	0.7	0.5571
DPQ	1.00	0.3186	0.89	0.4504
Shm (dB)	0.89	0.3461	0.48	0.6983
DPQ-A	1.00	0.3192	0.12	0.9498

From the F values depicted in the above table No.7 it is possible to arrive at a conclusion that except fundamental frequency measurements in adult male and females didnot show any significance of mean difference in any pitch Samplitude perturbation measures. The F value is below 3.18 and probability is above 0.07, As there is no difference between adult males and females, this data was also merged into a group making 180 samples in each parameter.

To examine whether there is any significance of mean difference between pitch and amplitude perturbation measures having different sample durations and different vowels, a two-way ANOVA was conducted for each pitch and amplitude perturbation. The results are tabulated below.

A.Fundamental Frequency (In normals) : The two-way ANOVA depicted that there was no significant difference between the mean of Fo measures having different sample durations (F = 0.00 & P>1.OO).

However, the same test depicted the means of Fo measures were different significantly across the vowels (F = 581.74, P>0.00).

These group analysis results were further confirmed at individual level by Newman-Kuel1's comparison test, the results are given below

TABLE 4.8. Table snowing significance of mean difference in Fundamental Frequency (S=significant at 0.05 level confidence) across different vowels (/a/, /i/ and /u/) on Newman-Kuel1's comparison test, (in normals).

	/a/	/i/	/u/
/a/	-	s	s
/i/	s	-	s
/u/	s	s	-

The test indicates the significance of mean difference at 0.05 level confidence across three vowels.

The Newmast Kvell's comparison test indicates that Fo measures are significantly different across all the vowels.

B) Jitter Ratio (in normals) : The 2-way ANOVA depicted that there was a significant difference between the means of J R measures having different sample duration (F < 33.9 and P>0.00). The same test also depicted the means of J R measures were different significantly across the vowels (F < 31.33 and P >0.00). These group analysis results werefurther evaluated and confirmed by 'Newman-Kuel1's comparison test. The results are given below:

TABLE. 4.9 : Table showing significance of mean difference in Jitter Ratio (S=significant at 0.05 level confidence) across different sample durations (0.5, 1, 2 and 3 secs.) on Newman-Kuell's comparison test. (in normals).

Durations	0.5	1	2	3 sees
0.5 Sec.	-	s	s	s
1 Sec.	s	-	-	-
2 Sec.	s	-	-	-
3 Sec.	s	-	-	-

The test indicates that J R was significantly different at 0.5 sec. when compared to J R values at 1 , 2, 3 secs at 0.05 level of confidence.

There was no significant difference between the means of J.R. measures having 1, 2 and 3 secs of sample durations.

TABLE 4.10 : Table showing significance of mean difference in Jitter Ratio (S=significant at 0.05 level confidence) across different vowels (/a/, /i/ and /u/) on Newman-Kuel1's comparison test, (in normals).

Vowels	/a/	/i/	/u/
/a/	-	s	s
/i/	s	-	-
/u/	s	-	-

The test indicates that JR measures was significantly different for /a/ vowel when compared to /i/ & /u/ whereas there was no significant difference in the J R measures between /i/ & /u/ vowels.

C. Directional Perturbation Quotient for Pitch (DPQ) (In normals)

The two way ANOVA depicted that there was no significant difference between the means of DPQ measures having different sample duration (F < 1.23 and P>0.2961). The same test also depicted the means of DPQ measures were significantly different across the vowels (F^-34.7 and P>0.000). These group analysis results were further evaluated and confirmed by 'Newman-Kuel1's comparison test. The results are given below :

TABLE 4.11. Table showing significance of mean difference in Directional Perturbation Quotient (S=significant at 0.05 level confidence) across different vowels (/a/, /i/ and /u/) on Newman-Kuell's comparison test, (in normals).

Vowels	/a/	/i/	/u/
/a/	-	s	s
/i/	s	-	-
/u/	s	-	-

The test indicates that DPQ measure was significantly different for /a/ vowel when compared to /i/ & /u/ where as there was no significant difference in DPQ measures between /i/ & /u/ vowe1s.

D. Shimmer (dB) (In normals) : The 2-way ANOVA depicted that there was no significant difference between the means of Shimmer(dB) measures having different sample durations (F<0.15 & P>0.9328). The same test also depicted the means of Shimmer(dB) measures were different significantly across the vowels (F<52.89 & P>0.000) These group analysis results were further evaluated and confirmed by 'Newmen-Kuel1's comparison test. The results are given below :

TABLE 4.12. Table showing significance of mean difference in Shimmer (dB) (S=significant at 0.05 level confidence) across different vowels (/a/, /i/ and /u/) on Newman-Kuel1's comparison test. (in normals).

vowels	/a/	/i/	/u/
/a/	-	s	s
/i/	s	-	-
/u/	s	—	—

The test indicates that shimmer (dB) measures was significantly different for /a/ vowel when compared to /i/ & /u/ whereas there was no significant difference in the shimmer (dB) measures between /i/ & /u/ vowels.

E. Directional Perturbation Quotient for Amplitude (DPQ -A) (In normals)

The two-way ANOVA depicted that there was no significant difference between the means of DQP-A measures having different sample durations i.e. 0.5, 1,2,& 3 seconds (F<0.03 & P>0.9922).

The same test also depicted the means of DPQ-A measures were significantly different across the vowels (F<8.58 & P>0.0002). These group analysis results were further evaluated and confirmed by 'Newman-Kuel1's comparison test. The results are given below :

TABLE 4.13. Table showing significance of mean difference in Directional Perturbation Quotient for Amplitude (S=significant at 0.05 level confidence) across different vowels (/a/, /i/ and /u/) on Newman-Kuel1's comparison test, (in normals).

Vowels	/a/	/i/	/u/
/a/	-	s	s
/i/	S	-	-
/u/	s	-	-

The test indicates that DPQ -A measures was significantly different for /a/ vowel when compared to /i/ & /u/ whereas there was no significant difference in the DPQ-A measures between /i/ & /u/ vowels.

To validate the results obtained from normal subjects, ten dysphonics were taken and the pitch and amplitude perturbution measures obtained from them. The data were subjected to the same statistical procedure and the results were tabulated as below :

A: Fundamental Frequency (Fo) (Dysphonics).

The two-way ANOVA depicted that there was no significant difference between the means of Fo measures having different sample durations (F<0.01 and P>0.9986). The same test also depicted the means of DPQ measures were not significantly different across the vowels (F<2.87 and P>0.0588), These group analysis results were further evaluated and confirmed by Newman-Kuell's comparison test. The results are given below =

TABLE 4.14. Table showing significance of mean difference in Fundamental Frequency (S=significant at 0.05 level confidence) across different vowels (/a/, /i/ and /u/) on Newman-Kuel1's comparison test, (in disphonics).

Vowels	/a/	/i/	/u/
/a/	-	s	s
/i/	s	-	-
/u/	s	-	

The test indicates that Fo measures were significantly different for /a/ vowel when compared to /i/ and /u/ whereas there was no significant difference in the Fo measures between /i/ & /u/ vowels.

B. Jitter Ratio (JR) (in Dysphonics)

The two-way ANOVA depicted that there was no significant difference between the means of J R measures having different sample duration (F<0.7 & P>0.5571). The same test also depicted the means of J R measures were different significantly across the vowels (F < 6.58 & P>0.0017). These group analysis results were further evaluated and confirmed by 'Newman-Kuel1's Comparison test.

The results are given below :

TABLE 4.15. Table showing significance of mean difference in Jitter Ratio (S=significant at 0.05 level confidence) across different vowels (/a/, /i/ and /u/) on Newman-Kuel1's comparison test, (in dysphonics).

Vowels	/a/	/i/	/u/
/a/	-	s	s
/i/	s	-	-
/u/	s	-	-

The test indicates that J R mesures was significantly different for /a/ vowel when compared to /i/ & /u/ whereas there was no significant difference in the J R measures between /i/ & /u/ vowels.

C. Directional Perturbation Quotient for Pitch (DPQ) (Dysphonics)

The two-way ANOVA depicted that there was no significant difference between the means of DPQ measures having different sample durations (F<0.89 and P>0.4504). The same test also depicted the means of DPQ measures were not significantly different across the vowels (F<0.6 & P>0.5476). These group analysis results were further confirmed by 'Newman-Kuel1's comparison test. The results indicate that there is no significant difference across different sample durations and different vowels.

D. Shimmer(dB) (Dysphonics).

The two-way ANOVA depicted that there was no significant difference between the means of Shimmer(dB) measures having different sample duration (F<0.48 & P>0.6983). The same test also depicted the means of shimmer (dB) measures were not different significantly across the vowels (F<2.05 & P>0.1316). These group analysis results were further evaluated and confirmed by 'Newman-Kuell's comparison test. The results indicate that there is no significant difference across different sample durations and as well as across different vowels.

E. Directional Perturbation Quotient for Amplitude (DPQ - A) (Dysphonics).

The two-way ANOVA depicted that there was no significant difference betwen the means of DPQ-A measures having different sample duration (F<0.12 & P>0.9498). The same test also depicted the means of DPQ-A measures were significantly different across the vowels (F<6.03 & P>0.0028). These group analysis results were further evaluated and confirmed by 'Newman-Kuel1's comparison test. The results are given below -

TABLE 4.16. Table showing significance of mean difference in Directional Perturbation Quotient for Amplitude (S=significant at 0.05 level confidence) across different vowels (/a/, /i/ and /u/) on Newman-Kuel1's comparison test, (in dysphonics).

Vowels	/a/	/i/	/u/
/a/	-	s	s
/i/	s	-	-
/u/	s	-	-

TABLE 4.17. Table showing mean and standard deviation in fundamental frequency of vowels /a/, /i/ and /u/ for normal males and females acorss different sampling frequencies (16 KHz and 8 KHz)

Sampling Frequency	Voice sample	Males	females
16KHz	/a/	138.98 (33.1104)	254.258 (36.9542
	/i/	140.73 (32.39)	262.89 (36.0368
	/u/	149.03 (40.486)	256.61 (34.6375)
8KHz	/a/	154.35 (43.9427)	253.18 (31.6976)
	/i/	146.75 (32.39)	255.25 (26.1745)
	/u/	149.39 (40.0244)	256.2 (25.1543)

Table 4.18. Table showing mean and standard deviation in Jitter Ratio of vowels /a/, /i/ and /u/ for normal males and females acorss different sampling frequencies (16 KHz and 8 KHz)

Sampling Frequency	Voice sample	Males	females
16KHz	/a/	159.64 (163.261)	135.22 (158.04)
	/i/	143.96 (160.0596)	137.36 (154.41)
	/u/	161.67 (187.6776)	107.03 (149.14)
8KHz	/a/	317.59 (134.013)	156.382 (155.3296)
	/i/	285.46 (117.8838)	146.115 (147.8979)
	/u/	266.97 (122.459)	124.5 (156.8868)

Table 4.19. Table showing mean and standard deviation in Directional Perturbation Quotient (DPQ) of vowels /a/, /i/ and /u/ for normal males and females acorss different sampling frequencies (16 KHz and 8 KHz)

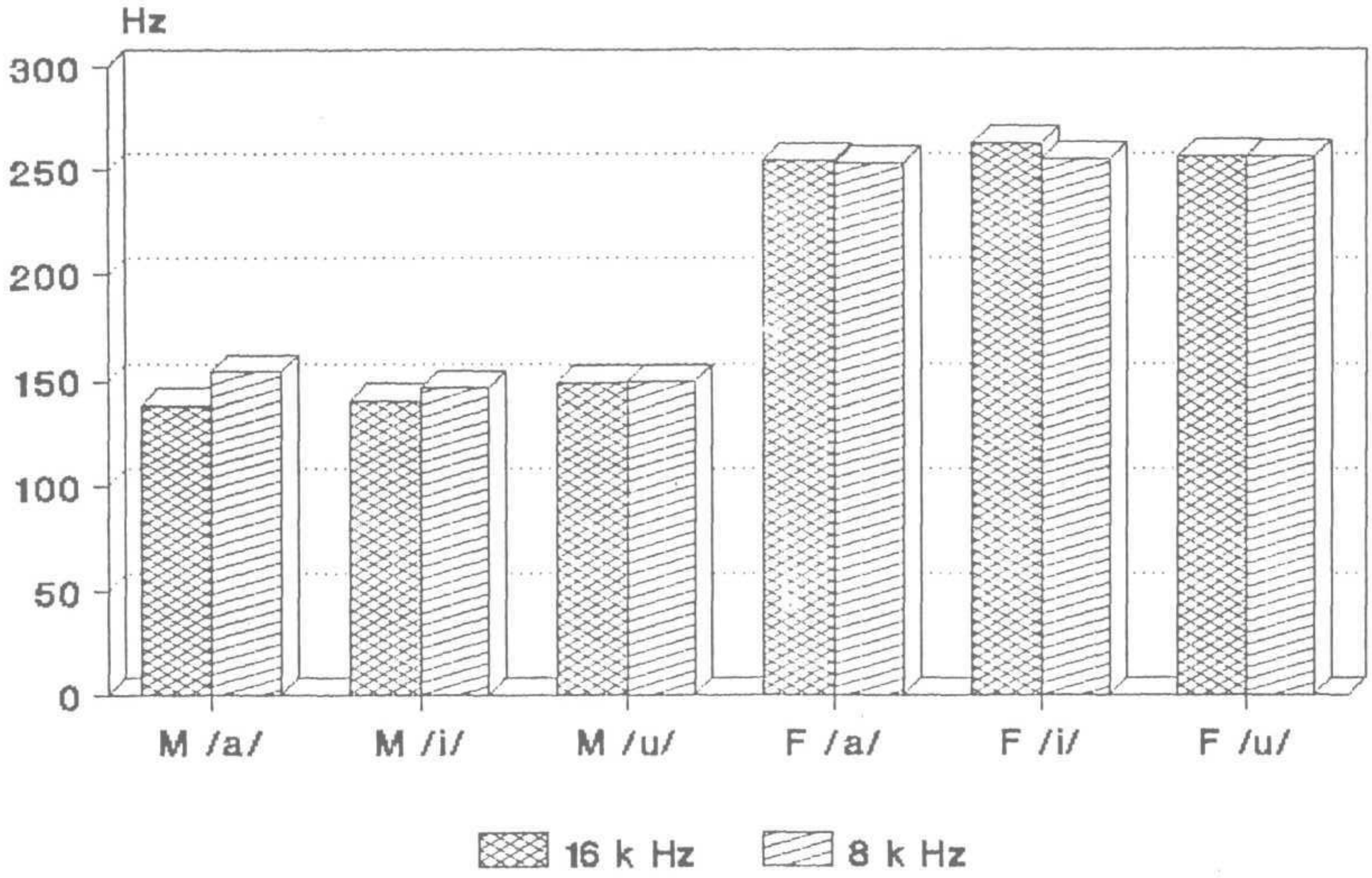
Sampling Frequency	Voice sample	Males	females
16KHZ	/a/	64.8142 (12-4341)	66.6999 (8.0736)
	/i/	61.4553 (14.9225	63.2041 (8.6444)
	/u/	62.7868 (15.5855	62.6168 (8.4304)
8KHz	/a/	71 .1227 (9.5248)	62.2667 (8.7383)
	/i/	70.401 (6.3675)	54.8114 (17.8923)
	/u/	68.7228 (7.2354)	60.7302 (8.5521)

Table 4.20. Table showing mean and standard deviation in Shimmer in (dB) of vowels /a/, /i/ and /u/ for normal males and females acorss different sampling frequencies (16 KHz and 8 KHz)
Shimmer (in dB)

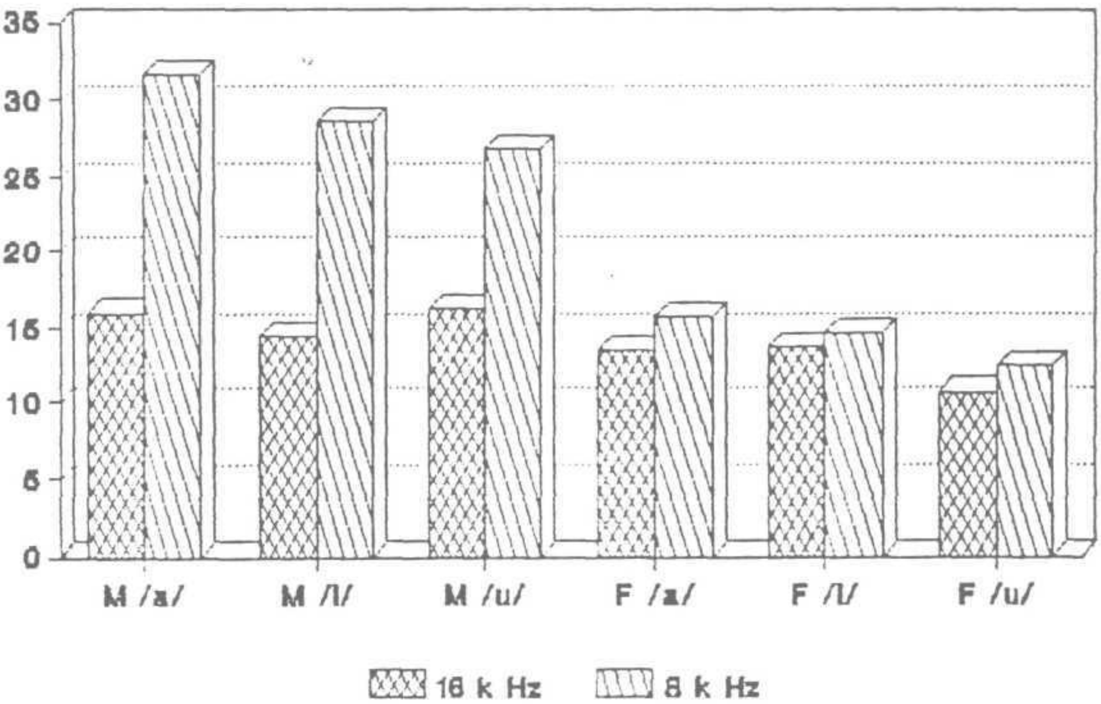
Sampling Frequency	Voice sample	Males	females
16KHz	/a/	1 .5795 (1.8813)	2.3417 (2.1331)
	/i/	1 .972 (2.7)	2.6373 (2.4046)
	/u/	1.0066 (0.9589)	1.6947 (1.3541)
8KHz	/a/	2.1621 (2.1724)	2.5781 (2.1381)
	/i/	2.0387 (2.1281	2.6463 (2.5887)
	/u/	1.3716 (1.2396)	2.0266 (1.6618)

Table 4.21 Table showing mean and standard deviation in Directional Perturbation Quotient for Amplitude (DPQ-A) of vowels /a/, */i/* and /u/ for normal males and females acorss different sampling frequencies (16 KHz and 8 KHz)

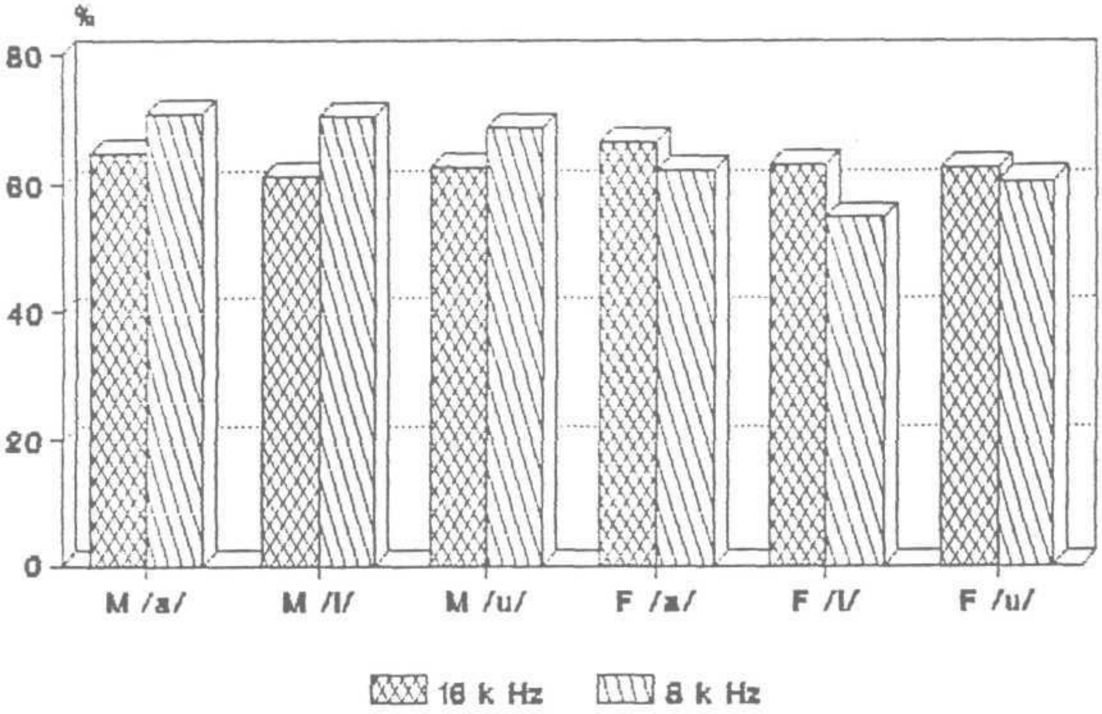
Sampling Frequency	Voice sample	Males	females
16KHz	/a/	63.5121 (3.7251)	57.5406 (11.6154)
	/i/	63.8446 (3.1417)	54.9719 (11.2219)
	/u/	64.7217 (2.7784)	57.9963 (9.706)
8KHz	/a/	64.1587 (3.1936)	47.8575 (24.2833)
	/i/	62.0041 (5.0937)	53.6089 (12.6002)
	/u/	64.8074 (3.3301)	57.5029 (10.1797)



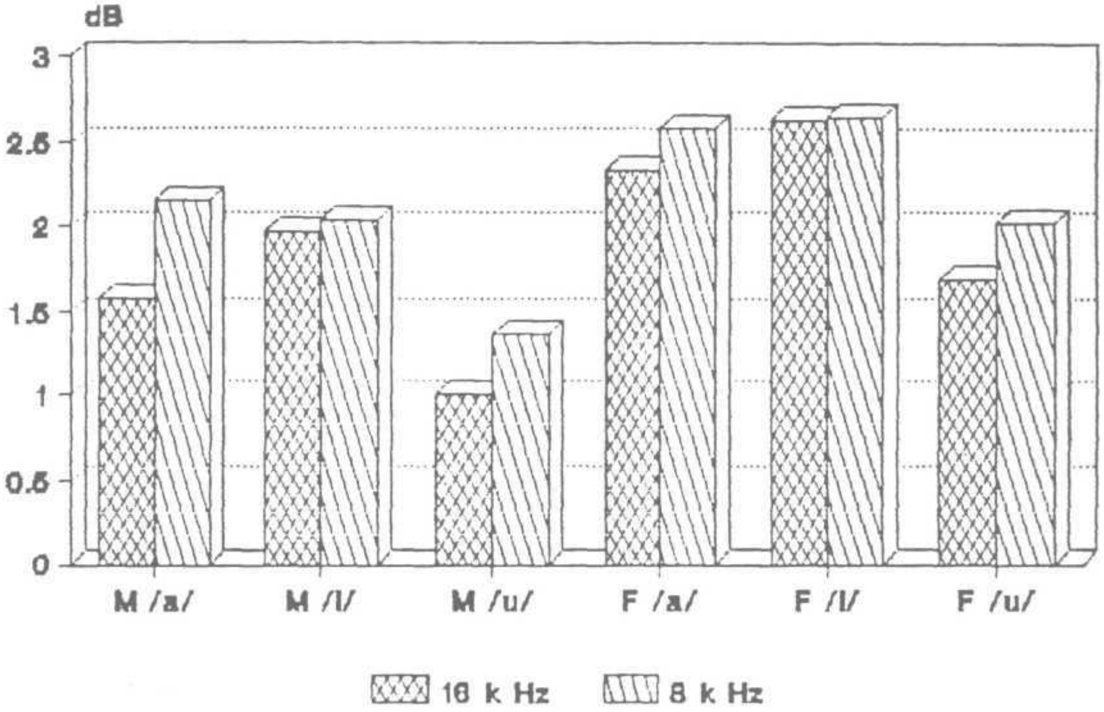
Graph 4.10 Fundamental frequency of normal males and females for vowels /a/, /i/, and /u/ across two sampling frequencies.



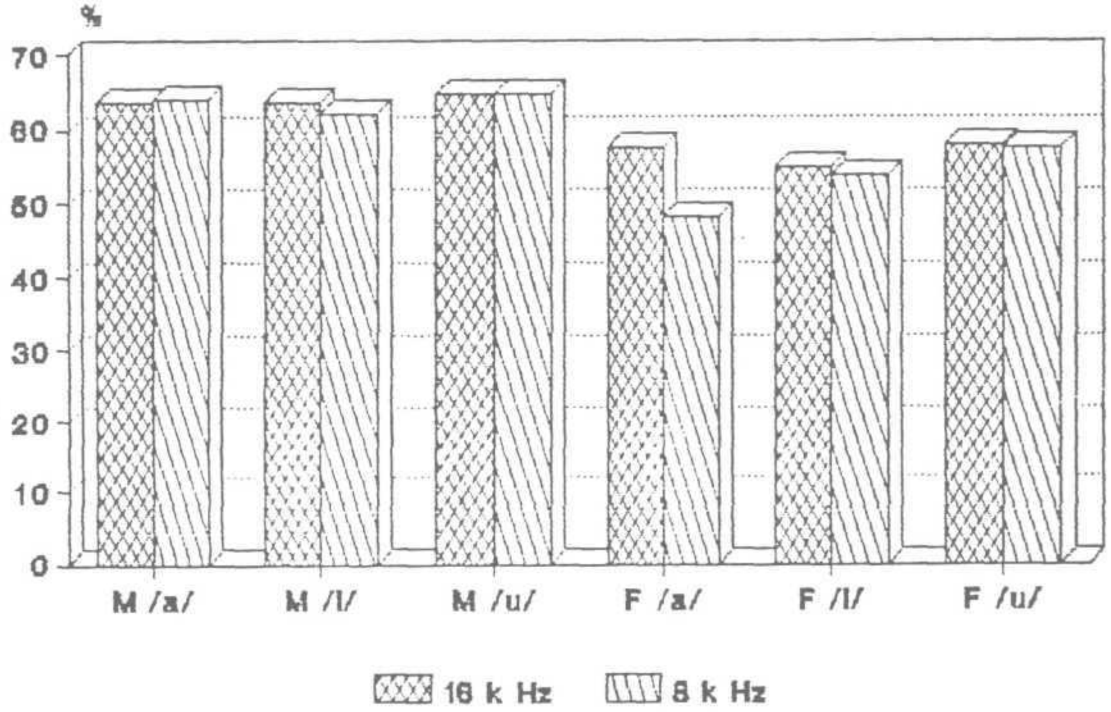
Graph 4.11 Jitter Ratio (JR) of normal males and females for the vowels /a/, /i/ and /u/ across two sampling frequencies.



Graph 4.12 Directional Perturbation Quotient (DPQ) of normal males and females for the vowels /a/, /i/ and /u/ across two sampling frequencies.



Graph 4.13 Shimmer (dB) of normal males and females for the vowels /a/, /i/ and /u/ across two sampling frequencies.



Graph 4.14 Directional Perturbation Quotient for amplitude (DPQ-A) of normal males and females across two sampling frequencies.

The test indicates that DPQ-A measures was significantly different for /a/ vowel when compared to /i/ & /u/ whereas there was no significant difference in the DPQ-A measures betwen /i/ & /u/ vowels.

Experiment-2

The aim of experiment-2 was to evaluate the effect of temporal resolution on pitch and amplitude perturbation measurement. Table 4.17 to Table 4.21gives the mean and standard deviation of Fo, JR, DPQ, Shm(dB), DPQ-A at different sampling frequencies. The same is depicted in the graph 4.10 to 4.14.

The Fo and Pitch amplitude perturbation measures were measured for the phonation of /a/, /i/, /u/ vowels each having three trials of phonation.

In an attempt to reduce the data, one-way ANOVA was conducted to know the significance of difference between the means of three different trials. The following table No. 4.22 provides you the F value and its probability for different sampling frequency and different groups of subjects.

TABLE 4.22 . Table showing F value and its probability between trials for different sampling frequencies (16 KHz & 8 KHz) for nomral males and females.

	Normal	males	Normal	females
	F	P	F	P
16KHz	1.08	0.3715	0.04	0.9659
8KHx	0.38	0.6895	0.96	0.41

By scrutinizing above table it can be stated that there was no significant difference, at 0.05 level, betweent the three trials of different measures of pitch and amplitude perturbations having different sampling frequency. Here F value is well below 1.08 and the probability was above 0.3715.

As there was no significant difference between the trials, the data of three trials were added, that made 15 samples in each group. Table No. 4.23.

TABLE 4.23. Table shoiwng F value and its probability across sampling frequencies 16 KHz and 8 KHz for male and female subjects.

	F	P
16KHz	0.57	0.4555
8KHx	2.34	0.1374

Further, to know the signifiicance of mean difference between males and females another one - way ANOVA was conducted and the F values depicted in the table No. 4.24. By viewing this table it is possible to arrive at a conclusion that there is no significant difference in means of any pitch and amplitude perturbation measures between males and females. The F value is below 0.57 and probability is above 0.1374. As there is no difference between adult males and females this data is also merged ito a group making 30 samples in each parameter.

To examine whether there is any significance of mean difference between pitch and amplitude perturbation measures digitized at different sampling frequencies, a 't' test was administered for each pitch and amplitude perturbation measures.

The results are tabulated below

TABLE 4.24. Table showing T value and its probability across different parameters (Fundamental Frequency, Jitter Ratio, Directional Perturbation Quotient for Pitch, Shimmer (dB) and Directional Perturbation Quotient for Amplitude for 16 KHz and 8 KHz sampling frequencies.

	T	P
Fo/a/	-1.15	0.259
Fo/i/	0.218	0.828
Fo/u/	0.999	0.326
JR/a/	-2.085	0.046
JR/i/	-2.11	0.045
JR/u/	-1 .43	0.1623
DPQ /a/	-0.3838	0.046
DPQ /i/	-2.11	0.0435
DPQ /u/	-1 .43	0.1623
Shm /a/	-1.0986	0.281
Shm /i/	-0.073	0.3154
Shm /u/	-1.009	0.3211
DPQ-A /a/	-0.1322	0.8957
DPQ-A /i/	0.4253	0.6737
DPQ-A /u/	0.1028	0.9188

1. Fundamental Frequency (Fo)

The t test depicted that there was no significant difference between the means of Fo measures having different sampling frequency as T value is less than 1.15 and P value is above 0.259.

2. Jitter Ratio : (JR)

On t test J.R. showed signifiicance of mean difference at 0.05 level, between 8KHz and 16KHz sampling frequency for /a/ and /i/ vowels. There was no significance of mean difference found for /u/ vowel between two different sampling frequencies. Since th T value is less than 2.11 and P above 0.0435.

3. Directional Perturbation Quotient (DPQ)

The 't' test depicted that there is no significant difference between the means of DPQ measures for different sampling frequencies since T value is less than 1.021 and P is above 0.3154.

4. Shimmer (dB)

The 't' test depicted that there is no significant difference between the means of shm(dB) measures for different sampling frequencies since T values is less than 1.0985 and P is above 0.281 .

5. Directional Perturbation Quotient for Amplitude (DPQ-A)

The 't' test depicted that there is no significant difference between the means of DPQ-A measures having different sampling frequency as T value is less than 0.4253 and P is above 0.673.

DISCUSSION

Experiment-1.

The survey of literature shows that there is no similar study which attempted to evaluate the effect of sample duration on pitch and amplitude perturbation measures. The present study attempted to do the same by measuring jitter ratio, DPQ, Shimmer (dB) and DPQ-A for different sample durations i.e., 0.5, 1, 2&3 seconds. The results which are presented earlier clearly state that except in jitter ratio other three pitch and amplitude perturbation measures did not show any mean difference across the different sample durations. Jitter ratio showed the mean difference between 0.5 sec, sample duration and other sample durations. However, there was no difference in the means of jitter ratio which were measured having 1, 2 and 3 second sample durations.

It was possible to conclude from these results that the influence of sample duration is minimal or negligible on pitch and amplitude perturbation measures. It was also possible to recommend that one second sample duration is sufficient to obtain a reliable and valid pitch and amplitude perturbation measures.

However, in the present study, only ten dysphonics were used to check the validity of the data obtained from normals. Hence it is recommended that another study may be conducted with a large number of dysphonics.

The results have also shown that there was no significant difference between three trials of phonation for pitch and amplitude perturbation measures. Hence it can be concluded that only one trial of phonation may be sufficient to obtain a reliable data on pitch and amplitude perturbation measurements.

In the same study it can also be observed that pitch and amplitude perturbation measures did not vary between /i/ & /u/ vowels. But these measures showed a significant difference when they were compared with pitch and amplitude measures of the phonation of /a/ vowel. By this it is also clear that for the purpose of clinical evaluation it is sufficient to obtain the phonation of only two vowels i.e., /a/ & /i/. Physiologically also these vowels are produced making the constriction at two extremely different positions in the oral cavity. The /a/ is low back vowel where as /i/ is high front vowel.

Experiment-2 : The results from this experiment suggest that the pitch and amplitude perturbation measures did not vary significantly across the two different temporal resolutions i.e., 16 KHz & 8 KHz, except in Jitter Ratio. The earlier studies which measured pitch and amplitude perturbation used sampling frequencies from 8.0 KHz to 50 KHz. (Horii (1980, 1985) had taken 40 KHz; Fritz & Frank (1985) had taken 25 KHz; Imaizuma (1986) had taken 20 KHz. Milenkovic (1987) had taken 8.3 KHz; Venkatesh , Sathya and Jenny (1992) had taken 16 KHz with interpolation).

In 1980, Melinkovic conducted a study and found that lower sampling rates are efficient enough to use in clinical setup. According to him the perturbation measures made using lower sampling frequency is not only efficient in differentiating different voice disorder but also has several improvements. The lower sampling rate is more readily obtained and processed using widely available low-cost desk top computers and low cost analog-to-digital converter hardwares. This low sampling rate reduces the processing time for calculation of perturbation measures and also reduces the space required to store the data. The results from present study also agrees with the Milenkovic (1987).

However, due to smaller sample size and lack of validation by using dysphonics, investigator is very careful in drawing conclusion. Eventhough, lower sampling rate is cost effective in terms of time and space, the quantizaton errors may be high and hence low reliability. Until an extensive study is carried out and the results of that study is favourable to lower sampling rate, it is suggested to use the sampling rate higher than 16 KHz with interpolation for the purpose of measurement of perturbation measures.

CHAPTER - V

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

Voice is the laryngeal modulation of pulmonary air stream which is further modified by the configuaration of vocal tract, (Michael and Wendhal , 1971.).

Voice plays an important role in speech communication. The production of voice requires a complex and precise control by the central nervous system on the a series of synchronous events in respiratory, phonatory and resonatory system. Any anatomical and physiological deviation in these systems would lead to voice disorder. The evaluation of voice includes acoustic analysis of voice. The acoustic analysis of voice may be one of the most powerful and attractive method for assessing the phonatory function as it is non-invasive, objective and quantitative.

One of the important and powerful acoustic neasure of voice is pitch and amplitude perturbation. These methods have been extensively used in voice clinics [Liberman (1961,1963); Koike (1973); Kitazima and Gould (1976); Horii (1979); Murry and Doharthy (1980); Askenfelt and Hammerberg (1986); Higgins and Saxman (1989); Venkatesh, Satya and Jenny (1992); Gokul Krishna (1992); and Pathak (1994)].

The measurement of pitch and amplitude perturbation is influenced by several factors. They are:-

1. Sample durattion.
2. Temporal resolution (Sampling frequency).

3. Pitch extraction method.
4. Type of microphone.

The various sample duration which were taken by different investigators was:- Horii, (1980 and 1985); Fritz and Frank (1985) had taken 3 secs, duration; Imaizuma (1985) had taken 0.5 sec duration.

The earlier studies which measured pitch and amplitude perturbation used sampling frequencies from 8 KHz to 50 KHz Horii (1980 and 1985) had taken 40KHz; Fritz and Frank (1985) had taken 25 KHz; Imaizuma S. (1986) had taken 20 KHz; Milenkovic P. (1987) had taken 8.3 KHz; Venkatesh, Sathya and Jenny (1992) had taken 16 KHz with interpolation; Raghunath, Baldva and Venkatesh (1992) had taken 16 KHz with interploation.

The present study is aimed at studying the effect of duration of voice sample and temporal resolution of perturbation measurements. The sample durations of 0.5 secs, 1 sec, 2 sec and 3 secs and temporal resolution of 8,000 Hz and 16,000 Hz are compared for their efficacy in the measurement of frequency and amplitude perturbations.

Thirty normal adult males, thirty normal adult females and 10 dysphonics served as subjects. The age range of normal subjects varied from 19 to 35 years, whereas the age range of dysphonics group varied from 30 to 55 years, three trials of EGG recordings for 5 seconds, for each of the vowels /a/, /i/ and /u/ were obtained using kay-laryngograph. The EGG recordings were digitized at 16 KHz sampling frequency using 12 bit Analog-to-Digital Converters. The digitized data was stored on the hard disk of PC-AT 386. The digitized EGG waveforms were smothened, differentiated and peak-picking method was used to extract the fundamental frequency and intensity. The obtained cycle-to-cycle fundamental frequency and intensity data were subjected to further computations using PC-AT 386 to obtain Jitter Ratio (JR), Directional Perturbation Quotient (DPQ), Shimmer in(dB), Directional Perturbation Quotient for Amplitude (DPQ-A).

Five normal adult males and five normal adult females with the age range of 18 to 25 years served as subjects for the second experiment. Three trials of EGG recordings for 5 seconds, for each of the vowels /a/, /i/ and /u/ were obtained using Kay-laryngograph. The EGG recordings were digitized at 16 KHz sampling frequency using 12 bit analog - to - Digital converter. The digitized data was stored on the hard disk of PC-AT 386. The digitized data was further digitally filtered for 3.5 KHz and then down sampled to 8 KHz and this data was also stored in a separate file. By this, it was possible to obtain a digitized data for the same voice at two different sampling frequencies i.e., 16 KHz and 8 KHz. The dizitized EGG wave forms were smoothened, differentiated, interpolated and peak picking method was used to extract fundamental frequency and intensity. The obtained cycle to cycle fundamental frequency and intensity data were subjected to further computations using PC-AT 386 to obtain Jitter ratio, Directional Perturbation Quotient, Shimmer (dB), and Directional Perturbation Quotient for Amplitude.

The measured pitch and amplitude perturbation valves were subjected to descriptive statistical procedures, t-test and to ANOVA. Based upon the results obtained the following conclusions were drawn :

1. There is no significant difference between the three trials for all the four measures of pitch and amplitude perturbations. Hence, it is not really necessary to take all the three trails for the measure of pitch and amplitude perturbation. Even a single trail can give same amount of information.

2) There was no significant difference between adult normal males and adult normal females for four pitch and amplitude perturbation measures.

3) There was a significant difference between the vowel /a/ and /i/, /u/ whereas these was no significant difference between the vowel /i/ and /u/ for the four measures of pitch and amplitude pesturbations. The difference observed between the low vowel i.e, /a/ and the high vowels i.e., /i/ & /u/ may be due to the different amount of laryngeal tension applied during the production of these vowels. Hence it is not necessary to take all the three vowels for the purpose of voice evaluation. The voice recording of one high vowel /i/ & one low vowel; /a/ is sufficient to obtain valid and reliable data for pitch and amplitude perturbation

4) There was no significant difference betwen different sample durations (i.e, 0.5, 1, 2 and 3 seconds) for DPQ, Shimmer (dB) and DPQ-A, whereas Jitter ratio (JR) showed that its values for

0.5 second sample duration is significantly different from other sample durations. (1, 2, 3 sec) J.R. did not show any significant mean difference across other three sample durations (i.e., 1, 2, & 3 seconds)

From the above result it may be infered that larger sample duration is not necessary to obtain a reliable and valid pitch and amplitude perturbation measures. Hence the recording of the voice sample for only one second is sufficient for the measurement of pitch and amplitude perturbation.

5) There is no significant difference between the two temporal resolutions. (16 KHz & 8KHz) for the measurement of DPQ, shimmer, dB & DPQ-A, however, in the measurement of Jitter Ratio there was significant difference between two temporal resolutions (i.e., 16 KHz & 8KHz). Due to the low experimental sample and varied results, it is not possible for the investigator to draw any concrete reliable inference, however, it may be suggested to use the sampling rate hihger than 16 KHz with interpolation for the purpose of measurement of perturbation measures.

LIMITATIONS :

1) The sample size of the dysphonic population taken for checking reliability and validity of the data was very small.

2) The sample size taken for the assessment of significant difference across different sampling frequencies (i.e, 16 KHz & 8 KHz) was very small to draw valid conclusions.

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