PITCH AND AMPLITUDE PERTRUBATION IN 7 *YEAR* OLD CHILDREN

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A DISSERTATION SUBMITTED IN PART FULFILMENT FOR THE DEGREE OF M.SC.[SPEECH AND *HEARING*] *TO THE UNIVERSITY OF MYSORE, MYSORE*

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1992

CERTIFICATE

This is to certify that the Dissertation entitled "PITCH AND AMPLITUDE PERTURBATION IN 7 YEAR *OLD* CHILDREN" is *the bonafide work in partial fulfilment for Second year* M.Sc. (Speech *and Hearing) of the student with Register No:* M *9008*

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This is to certify that this Dissertation entitled "*PITCH AND* AMPLITUDE PERTURBATIONS IN 7 YEAR *OLD* CHILDREN" *has been prepeared under my supervision and guidance.*

6 May 92

MYSORE
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VECLARATJON

This Dissertation entitled ***"PITCH AND*** **AMPLITUDE PERTURBATION IN 7 YEAR** ***OLD CHILDREN"*** *is the result* of *my own study, undertaken under the guidance of Dr.* R. S. *Shukla, Lecturer Department of Speech Pathology,* AIISH, *Mysore and has not been submitted earlier at any University for any other diploma or Degree*

My&onz
May 1992 REGISTER NO. M *9008*

Ajay for. his Love.

that gives ,

today its meaning

tomorrow its promise

and forever its dreams!!

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Ajay - MV LOVE
MY LIFE
My FRIEND
MV EVERYTHING

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INTRODUCTION

Speech communication is a transfer of information from one person to another via speech which consists of acoustic waves. The chain of events from conception to the message in the speakers brain to the arrival of the message in the listener's brain is called the speech chain.

The chain consists of a speech production mechanism located in the speakers brain and a transmission through a medium such as air and a speech perception process in the ears and brain of the listener.

Speech production can be viewed as a filtering operation in which a source (laryngeal waveform) excites a vocal tract filter and consists of voicing, articulation, and resonance resulting in a speech sound segment. With a view to gain knowledge about the details of speech production mechanism each of its stages have been studied and the processes are being deeply researched.

Voice science is one such important specialization as voice plays an important role in speech communication. The production of voice requires a complex and precise control by the Central Nervous System of a series of synchronous events in the peripheral phonatory organs, namely - respiration, phonation, articulation and resonance.

Voice is the laryngeal modulation of the pulmonary airstream which is further modified by the configuration of the vocal tract (Michel & Wendahl, 1971).

Hence anatomical/physiological deviation in any of these systems would lead to voice disorders.

A voice disorder be it in adults or children poses a challenge for the speech pathologist, more so in children.

The causes of voice disorders in children are many. It may range from a simple misuse/abuse of voice leading to organic conductions such as vocal nodules, vocal polyps, hyperkeratosis, nonspecific laryngitis to congenital anomalies of laryngeal structures. The voice can be disordered due to neurological reasons, tumor, trauma ,infections and developmental disorders such as hearing loss, mental retardation and cerebral palsy.

The management of disordered voice in children require a detailed assessment and a comprehensive therapeutic strategy.

The diagnostic procedure includes:

(1) To describe the nature and the extent of the disorder.

(2) To determine the causes of the voice disorders.

(3) To determine the degree and the extent of the causative factor.

(4) To determine the prognosis of the voice disorders as well as that of the cause of the disorders.

There have been many attempts over the years to find out reliable and objective methods that aid in early detection, diagnosis and treatment of voice disorders. This resulted in different methods of evaluation such as Acoustic, Aerodynamic, Physiological and Perceptual methods. Of these methods, Acoustic evaluation has a promising future as a diagnostic tool because:

(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) It is non-invasive and provides objective and quantitative data.

Of the number of acoustic correlates of voice. Probably Pitch and Amplitude Perturbation factors have been extensively studied by a number of researchers [Lieberman,1961; Von Leden; Moore & Timke, 1960; Hecker & Kruel,1971; Sorenson & Horii, 1984; Horii, 1984; Hollein Michel & Doherty, 1973; Murry & Doherty, 1980; Venkatesh, Satya & Jeny, 1992; Venkatesh, Neelu & Raghunath, 1992] to quantify the usefulness of these correlates in the diagnosis of voice disorders.

Michel and Wendhal (1971) were among the first researchers to list many Acoustic and Aerodynamic correlates of voice and discuss the usefulness of these correlates in the diagnosis and differential diagnosis of the voice disorders.

Of the many acoustic correlates, Pitch and Amplitude Perturbation measurements are the most extensively researched and documented.

Small variations (perturbations) in amplitude and frequency i.e. cycle-to-cycle variations in Fo (Pitch Perturbation or Jitter) and cycle-tocycle variation in intensity (Amplitude perturbation or Shimmer) are known to be natural ingredients in normal voice [Lieberman, 1961].

The voice produced by the vibrations of the vocal cords though generally believed to be periodic, no two cycles in a given vibration are identical. Therefore in reality voice is quasiperiodic, and hence, some amount of voice perturbation is normal and may reflect random aerodynamic and muscular events [Titze, Horii and Scherer, 1987] and infact such perturbation are important for the natural quality of voice [Holmes 1962].

However, large perturbations reflect alternations in the normal vibratory patterns of the vocal fold [Von Leden, Moore and Timke, 1960] and are often associated with laryngeal dysfunction.

A review of literature [Moore and Thompson, 1965, Moore and Von Leden,1958] reveals that speakers with vocal pathologies display greater pitch and amplitude perturbations indicating that frequency and amplitude perturbations are sufficiently sensitive to pathological changes in the phonatory process and perhaps even to severe respiratory insufficiency [Gilbert, 1975].

Several investigators [Lieberman, 1961; Von Leden, Moore and Timke, 1960; Hecker and Kruel, 1971; Sorenson and Horii, 1984, Horii, 1984; Hollein, Michel and Doherty, 1973; Murry and Doherty, 1980; Venkatesh, Satya and Jeny, 1992; Venkatesh, Neelu and Raghunath, 1991] have measured Jitter and Shimmer in normals and dysphonics for the purpose of diagnosis and differential diagnosis.

The normative data provides a basis for comparing Jitter and Shimmer values in the voices produced by patients having vocal pathologies (Eg. Polyps, nodules, other vocal pathologies) with voices of the healthy individuals.

The data collected so far on Pitch and Amplitude Perturbation is for the adult population and there- is no data on the younger population.

Pitch and Amplitude Perturbations data in normal children is necessary because of the following reasons:

(1) The anotomy and physiology of the child larynx is lot more different from that of adult.

(2) Children undergo neuromuscular maturation upto the age of 12

years and thereofre, children under 12 years may show greater variations on these measures.

(3) In children the change in voice is a continuous process until puberty. Therefore Jitter and Shimmer values may also differ across different age groups.

(4) Lastly some of the voice disorders like vocal nodules and polyps are more common in children than in adults. Therefore there is a greater need to identify the voice problems early in case of children. Hence the present study.

The present study aims at:

(1) Providing normative data for the following Pitch and Amplitude Perturbation measurements in 7 year old normal male children.

(a) Jitter Ratio (JR)

(b) Directional Perturbation Factor for Frequency (DPF-Frequency)

(c) Relative Average Perturbation (RAP - 3 Point)

(d) Shimmer [S(dB)]

(e) Direction Perturbation Factor for Amplitude (DPF-Amp.)

(f) Amplitude Perturbation Quotient (APQ)

(2) To compare the values of the above Jitter and Shimmer measurements with those of adult normative data in order to verify whether children's data differ from adult's data as per theoretical expectations.

(3) To compare the values of Jitter and Shimmer measurements with 8 year and 10 year old normal male children (data being collected simultaneously with this study by others) in order to verify whether the continuous voice changes taking place in children before puberty because of neuromuscular maturation brings changes in Jitter and Shimmer values across different age groups.

REVIEW OF LITERATURE

The primary mode of communication is speech. Voice is the vehicle of communication. Voice has been defined as "the laryngeal modulation of the pulmonary airstream which is further modified by the configuration of the vocal tract" (Michel & Wendahl, 1971).

Voice basically has three parameters viz. pitch, loudness and quality. Hence, the examination of voice should cover each of these parameters separately and in combination. Quality of voice is primarily dependent on pitch and pitch in turn depends on the vibration of the vocal folds. Thus, it becomes extremely essential to study the vibratory movement of the vocal folds for a thorough understanding of normal and abnormal voice production.

Various procedures have been adopted in order to study the vibratory patterns of the vocal folds, most of which can be used as diagnostic procedures. These diagnostic procedures comprise of tests that elicit information regarding the actual process of voice production and the nature of the sound generated. The purposes of the diagnostic procedures are:

(1) To determine the cause of the voice disorder.
(2) To determine the degree and extent of the causative factor.
(3) To evaluate the degree of disturbance in phonatory function.
(4) To determine the prognosis of the voice disorder as well as that of the cause of the disorder.
(5) To establish a therapeutic programme.

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 [Koike, 1969; Yanagihara, 1967].

High speed cinematography [Von Leden et.al, 1960], electroglottography [Fourcin and Abbetron, 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 been problems with instrumentation, methodology and analysis. In addition, invasive techniques like endoscopy, stroboscopy and the like present varying degrees of risk and discomfort for the patient [Koike 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.

Many acoustic parameters derived from 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.

What are 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 voices 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 fluctuations. These Jitter and Shimmer parameters are also called as pitch and amplitude perturbations.

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 Timcke, I960], Variations of fundamental frequency (period) and amplitude of successive glottal pulses in particular, are often referred to as "jitter" and "shimmer" respectively [Heiberger & Horii,1982]. Earlier methods of anlysis for "jitter" and "shimmer[1] were oscillographic analysis, glottal wave function, analysis via laryngoscopic high-speed photography.

Because of the minute nature of the parameters and because of limitations of above measurement techniques, the measurements of pitch and amplitude perturbations were time-consuming and difficult and normative data on jitter and shimmer have been slow to accumulate. With the invention of computers and computer based techniques, earlier methods of measuring shimmer and jitter are no more used in order to obtain precise and a quick data.

As explained earlier, the cycle-to-cycle variations in period that occur when an individual is attempting to sustain phonation at a constant frequency has been termed as jitter er pitch perturbation. It is the measurement of how much a given period differs from the period that immediately precedes it. It is a measure of frequency variability not accounted for by voluntary changes in fundamental frequency and is thus an acoustic correlate of erratic vibratory patterns. [Beckett, 1969]. Similarly, cycle-to-cycle variation in the amplitude in phonation has been termed as shimmer or amplitude perturbation.

Several investigators have reported the presence of small variations in fundamental frequency and/oramplitude of glottal vibration in normal voice [Horii, 1979, 1983, 1985; Hollien et.al, 1973; Sridhar, 1986] Others explain that they result from diminished control over the phonatory system (Sorenson, Leonard, 1980].

Physiological interpretations of jitter and shimmer in sustained phonation should probably include both physical and structural variations and myoneurological variations during phonation [Horii & Heiberger, 1982]. Structural and biochemical asymmetrices of the vocal folds are known to contribute to perturbation [Hirano, Ishiki, Imazzumi, Kakita & Matsushita, 1979] in addition to the random effects of laryngeal mucus and airflow.

Limitations of the laryngeal servo mechanism through the articular myotactic and mucosal reflex systems [Gould and Okamura, 1974; Wyke,1967] may also introduce small perturbations in the laryngeal muscle tones. The laryngeal muscle tones may have inherent perturbations due to time staggered activations of motor units that exist in any voluntary muscle contraction [Baer,1980]. A neuromuscular model of fundamental frequency perturbation has been described by Baer(1980) who attributed the vocal jitter to the inherent method of muscle excitation. A similar model has been developed by Titze (1988, a,b) and recent work by Larson and Kemster (1983) and Kistler (1987) has lent support to the notion that slight changes in vocal fold length and stiffness caused by intrinsic laryngeal muscle single-motor-unit twiches, can and do affect vocal fundamental frequency in a highly variable manner. Lieberman (1963) reasoned that frequency perturbations reflect :

(1) changes in glottal periodicity
(2) alterations of the glottal waveforms
(3) variations of vocal tract configuration that results in the phase shift of the acoustic waves.

Jitter measures either magnitudinal or directional derived from connected speech need to be interpreted with caution since both systematic perturbations due to phonetic context, stress and intonation and random perturbations associated with physiologic limitations of the glottal sound source co-exist in such voice signals. Thus, sustained vowel productions seem to be the most appropriate phonatory task when more or less random perturbations are caused by physiological variations alone.

Baken & Cavallo (1984) report that absolute jitter measures were much greater in pulse registers as compared to modal register phonation in normal adults.

Elderly speakers are more variable on frequency stability measures than young speakers [Wilcox & Horii, 1980 ; Stoicheff, 1981; Linville & Fisher, 1985a, b] Linville (1988) attempted to •gather information on the extent to which intraspeaker variability on measures of jitter and fundamental frequency standard deviation is age-related in women. He concluded that the aging process brings about increases in variability individual women demonstrate on measure of fundamental frequency stability when producing sustained vowels. Young speakers not only tended to display lower levels of jitter and fundamental frequency standard deviations than the elderly, but also demonstrated lower levels of intraspeaker variability in these measures. Moreover, the aging effect was particularly strong for the vowel /a/.

Sorenson and Horii (1983) have indicated that shimmer values are lesser in males (0.25dB) whereas jitter values are higher in females than males (0.84%). Thus it would be erroneous to assume female voices as similar to males.

On the contrary, Ludlow et.al (1984) have reported significantly lower jitter values for women than for men.

Clinicians can expect relative perturbations to be somewhat higher in high frequency voices while absolute jitter magnitude should decrease with increasing fundamental frequency. Jacob (1968) and Horii(1979) found that mean jitter decreased with corresponding increase in fundamental frequency.

Orlikoff and Baken (1990) studied the relationship between fundamental frequency and jitter for normal adults and concluded the following:

(1) when averaged over samples representing a significant portion of their phonational frequency ranges, jitter values of men and women do not seem to be significantly different.

(2) the relationship between fundamental frequency and jitter is obviously nonlinear.

(3) Jitter of women's voices is much less strongly influenced by changing vocal fundamental frequency than in case of men.

Orlikoff and Baken (1989) have studied the effect of heartbeat on vocal fundamental frequency and frequency perturbation and have found that heartbeats accounted for about 7% of the measured frequency perturbations in the voices of normal adult men ranging from approximately 0.5% to almost 20% for a given population. These data indicate that the reliability of jitter measurements is nonrandomly influenced by heartbeat related phenomena.

Vocal intensity may be a factor to be considered [Jacob,1968] found that jitter ratio tended to reduce with increasing vocal intensity.

The question of whether jitter varies systematically across different vowels is as yet unresolved. Wilcox and Horii(1980) and Horii (1980) found /a/ & /i/ had significantly greater jitter than /u/ for normal adults, whereas Johnson and Michel (1969) observed a tendency for high vowels to show greater jitter than low ones. Sorenson and Horii(1983) found significantly more jitter for /i/ than /u/ and /a/ as produced at comfortable pitch and loudness by women.

A large body of literature [Lieberman, 1961, 1963; Koike, 1969, 1977; Michel and Wendahl, 1971; Iwata and Von Leden, 1970, 1972,; Hecker and Kruel, 1971; Kitajima et.al, 1975; Davis, 1976; Deal and Emanuel, 1978; Horii, 1979; Murry and Doherty, 1980; Haji et.al, 1986] suggest that measures of jitter and shimmer are important determinants of voice quality. The presence of excessive jitter and/or shim;mer in the voice causes an abnormal voice quality and therefore is indicative of laryngeal dysfunction.

Data on Pitch and Amplitude Perturbations in Normals and Dysphonics in adults:

Many studies emphasize on the importance of using jitter and shimmer measurements in differential diagnosis of laryngeal pathologies.

Lieberman, Von Leden (1961); Moore and Timke (1960) studied pitch perturbation factors in six male subjects and other pathological subjects and concluded that pathological subjects had larger values than normals at similar pitch levels.

Several researchers have studied parameters like jitter ratio (Horii, 1978), jitter factor [Hollien, Michel & Doherty, 1977, Murry & Doherty, 1980] , relative average perturbations (Koike), frequency perturbation quotient [Takahashi & Koike, 1975], deviation from linear trend [Ludlow, 1983], directional jitter factor [Murry and Doherty, 1980] and have compared various parameters between normal and pathological voices. Deal and Emanuel (1978) measured period variability index in 20 male subjects with hoarseness and 20 male normal subjects and reported higher values in cases of subjects with hoarseness.

Hecker & Kruel (1971) and Murry & Doherty (1980) measured directional jitter factor for normals as well as patients suffering from laryngeal cancer. They concluded directional perturbation factor was sensitive enough to distinguish between normals and cancer patients.

Koike (1969) studied vowel amplitude perturbations,. 15 subjects with laryngeal neoplasms, 6 with unilateral laryngeal paralysis and 20 normal subjects and concluded that these perturbations in pathologic speech do bear some information about laryngeal pathology and this can be of some assitance in the evaluation of laryngeal dysfunction and perhaps in early detection of laryngeal pathologies.

Crystal and Jackson (1970) studied frequency and amplitude perturbations in voices of persons with varying laryngeal conditions and concluded that they serve as guidelines in detecting underlying pathology.

Kitajima, Gould (1976) studied vocal shimmer in 45 normal subjects and found it to range between 0.04 dB and 0.21 dB. They also studied 25 subjects with vocal polyp in whom the shimmer values were between 0.08 to 3.23 which was significantly higher, hence, they concluded that shimmer was a useful parameter in detecting laryngeal pathologies. Another study was conducted by Haji, Horiguchi, Baer and Gould(1986) in normals and pathological cases and they found that amplitude perturbations were more sensitive to irregularities of vocal fold vibrations and could differentiate between moderate and slightly hoarse voices.

Koike, Takahasi and Calcoterva (1977) studied perturbations in the fundamental pitch and in peak amplitude of the acoustic signal derived with a contact microphone system for the purpose of developing useful measures for detection of laryngeal pathology. Sixtythree patients with various laryngeal pathologies (cancer, tumour, nodules, polyps, paralysis, laryngitis) and 31 normal subjects were studied. Frequency perturbation quotient and average perturbation quotient values were studied. They found normal subjects occupy a rather limited area, while pathological cases disperse over a wide range of values.

Zyski, Bull, Mc Donald and Johns (1984) took up 7 acoustic parameters viz average percentage pitch perturbation(APPP), relative average perturbation(RAP), average pitch perturbation(APP), relative average amplitude perturbation(RAPP), average amplitude perturbation(AAP), average percentage amplitude perturbation (APAP)and shimmer in normals as well as pathologic larynges and concluded that all these parameters significantly differentiated normal and pathologic group means. Out of these, APPP was the best, followed by RAPP, then AAP and finally APP. They concluded that pitch perturbation measures were better (rather more effective) than amplitude perturbations for making such distinctions.

Various studies have shown a good correlation between acoustic and perceptual analysis in dysphonics and most of them have found a good correlation betwen the same. [Askenfelt 1986, Hartman and Von Cramon, 1984].

Imaizumi (1986) gave acoustic correlates of roughness based on results of earlier perceptual measurements. They found voices with large PPQ and APQ to be perceived as rough. But some voices with smaller values were also perceived as rough. They concluded that irregularity itself may not be necessarily essential for perceptual judgements.

Kane and Wellen (1985) have studied jitter and shimmer measures in children (10 subjects) with vocal nodules and have found these values to be significantly higher than the normal control group.

Linville (1987) studied voice perturbations of children with perceived nasality and hoarseness and found that jitter values were significantly greater in these children as compared with children without velopharyngeal incompetence.

Glaze et.al(1988) reported that acoustically derived voice perturbations of children decreased with increased loudness. A positive correlation between shimmer and perceived hoarseness was observed.

Linville (1987), Glaze et.al (1988) suggest that vocal shimmer may be quite variable among children.

As far as Indian population is concerned, Venkatesh, Satya,and Jeny(1992) have conducted pioneering research in this area. They have established normative data on 30 males and 30 females in theadult population. Moreover, they have studied shimmer and jitter in 30 dysphonics. They have found jitter and shimmer parameters to be higher in dysphonics as compared to normals. Moreover, they have reported that shimmer (dB) could be an effective measure to make such distinctions. Other researchers have studied jitter and shimmer parameters in dysphonics, hearing impaired children and cleft palate cases of varying age groups comparing them with normal control groups [Balaji, 1988; Sridhara, 1986; Chandrashekar, 1985; Prakash, 1991, Biswas, 1991] and have found jitter and shimmer values to be higher in the pathological groups as compared to normals.

METHODOLOGY

Several investigators have studied the Pitch and Amplitude Perturbation measurements, both in normal subjects and in subjects with laryngeal pathologies. The results of these studies show that Pitch and Amplitude Perturbations are larger in subjects with laryngeal pathologies. These findings suggest that Perturbation measurements of Frequency and Amplitude can be used in the diagnosis of laryngeal disorders. So the need was felt to establish normative data for different age groups.

The present study was aimed at establishing normative data for the following Pitch and Amplitude Perturbation measurements in thirty 7 year old normal male children, as there was no data available on these perturbation measurements in children.

I> PITCH PERTURBATION MEASUREMENTS;

a) Jitter Ratio(JR): is the mean perturbation divided by the mean waveform duration when done in terms of period [Horii, 1979].

b) Directional Perturbation Factor for Fequency(DPF-Frequency): takes into account only the direction and not the magnitude. It is defined as the percentage of the total number of differences in frequency for which there is a change in algebraic sign [Hecker & Kreul,1971).

c) Relative Average Perturbation (Three point)(RAP-3 point): is defined as a comparative average of change at three different points. It was given by Koike (1973).

II> AMPLITUDE PERTURBATION MEASUREMENTS:

a) Shimmer(dB) [S(dB)]: is defined as cycle to cycle variation in amplitude measured in decibels.

b) Directional Perturbation Factor for Amplitude(DPF-Amp) : takes into account only the direction and not the magnitude. It is defined as the percentage of the total number of differences in amplitude for which there is a change in algebraic sign [Hecker & Kreul, 1971].

c) Amplitude Perturbation Quotient (APQ).

SUBJECTS:

Thirty, Seven year old normal male children ranging—from years to years served as subjects for the study. The subjects were chosen based on the following criteria,

(i) Normal E.N.T. findings

(ii) Normal audiological findings

(iii) Normal intelligence

(iv) No known history of voice problem, vocal abuse or other relevant history of vocal pathology.

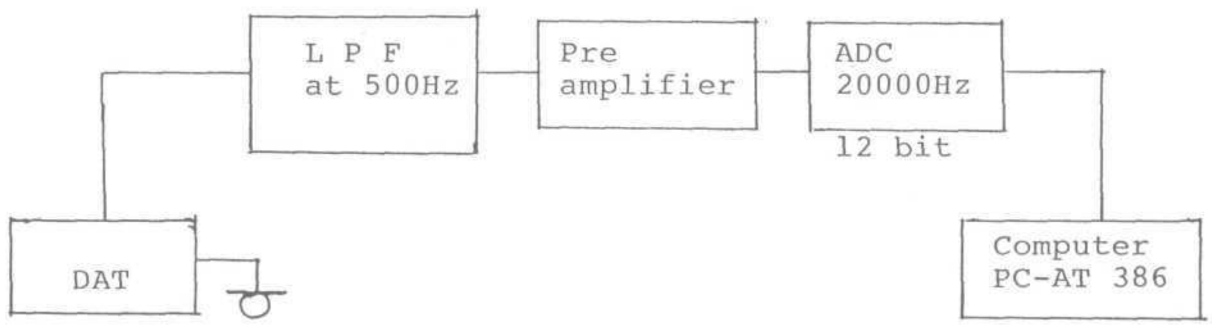
SPEECH SAMPLE:

Speech sample consisted of phonation of the vowels /a/, /i/ and /u/ for five seconds each. The subjects were required to phonate the three vowels by keeping the voice as steady as possible and at habitual pitch during the phonation. They were required to phonate the three vowels /a/, /i/, and /u/, thrice and hence the speech sample consisted of 9 phonations of 5 seconds each per subject. It was intended to take middle one second phonation for Pitch and Amplitude Pertubation analysis.

RECORDING:

The subjects were seated comfortably in front of a microphone situated in a sound treated room. The microphone was connected to a digital tape recorder (Sony DAT TCD-T3) The subjects were instructed to phonate the vowel /a/, /i/ and /u/ for 5 seconds at habitual pitch and at comfortable loudness. They were also instructed not to move their head and neck during phonation. All the subjects were provided with a practice session of 5 to 7 minutes, using Vocal II prior to the recording. This helped the children to produce steady phonations. The distance between the speaker's mouth and the microphone was 15 to 20cms, during recording. For each phonation sufficient time gap was given for the intake of air for the next phonation.

PITCH AND AMPLITUDE PERTURBATION ANALYSIS: [Schematic Diagram]



The output of the tape recorder was low pass filtered at 500Hz and feed to an A/D converter for digitization. The digitization was done with a sampling frequency of 20KHz using a 12bit ADC Cord. The digitized phonations were stored in a PC-AT386 and were analyzed for the Perturbation measurements using Vaghmi Software developed by Voice and Speech Systems, Bangalore.

(i) Jitter Ratio(JR):

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

P_i = Period of i^{th} cycle in ms

n = Number of periods in the sample

(ii) Directional Perturbation Factor for Frequency [DPF]

(iii) Relative Average Perturbation (Three point) [RAP-3point]

n -))

(iv) Shimmer (dB) [S(dB)]:

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

(v) Directional Perturbation Factor for Amplitude (DPF):

(vi) Amplitude Perturbation QuotienttAPQ]:

$$APQ = \frac{\frac{1}{n-10}\sum_{i=6} \left| A_{i-5} + A_{i-4} + \cdots A_i + \ldots A_{i+5} \right| - A_i}{\frac{1}{n}\sum^{n} A_i}$$

Analysis of all the above six parameters were done and the values were recorded.

STATISTICAL ANALYSIS:

Descriptive statistics (mean and standard deviations) applied on the data obtained. Analysis of variance / administered, followed by Duncan's Multiple Range test

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RESULTS AND DISCUSSION

The purpose of the study was to measure Pitch and Amplitude Perturbations in terms of Jitter Ratio, Directional Perturbation Factor for Frequency, Relative Average Perturbation (3 point), Shimmer (in dB), Directional Perturbation Factor for Amplitude and Amplitude Perturbation Quotient in 7 year old normal male children.

TABLE-1 shows the means and standard deviations for Jitter Ratio (JR), Directional Perturbation Factor for Frequency (D.P.F. -Freq.), Relative Average Perturbation (RAP - 3 point), Shimmer (S in dB), Directional Perturbation Factor for Amplitude (DPF-Amp.), Amplitude Perturbation Quotient (APQ) for the three vowels /a/, /i/ & /u/.

	J.R.	DPF(freq)	RAP(3 pt)	S(dB)	DPF(Amp)	APQ
/a/	9.54 (2.03)	63.63 (3.23)	0.0063 (0.0022)	0.34 (0.09)	64.25 (3.29)	2.18 (0.59)
/i/	12.23 (2.46)	67.14 (2.51)	0.0100 (0.0046)	0.24 (0.08)	62.68 (4.96)	1.69 (0.50)
/u/	12.54 (2.15)	66.91 (2.80)	0.0121 (0.0165)	0.22 (0.07)	59.81 (11.10)	1.57 (0.46)

TABLE-1: Showing the means and standard deviations for JR, DPF-Frequency, RAP-3 Point, S(dB), DPF-Amp, APQ for the three vowels /a/, /i/ and /u/.

Since 30 normal 7 year old male children were studied, this data can be considered as normative for the population of same age and sex

To know whether the six parameters differed with respect to vowels studied, a one-way ANOVA was administered separately for each of the 6 parameters followed by DMRT (Duncan Multiple Range Test). The results of the six ANOVA tests have been summarized in TABLE-2.

PARAMETER	DEGREES OF FREEDOM	F-RAT10	S/NS
J R	2 87	16.51	***
DPF (for frequency)	2 87	14.13	***
RAD (3 point)	2 87	2.63	ns
S (in dB)	2 87	17.16	***
DPF (for amplitude)	2 87	2.88	ns
APQ	2 87	11.52	***

S/ns = Significant/not significant

*** = highly significant

TABLE-2 : The results of one way ANOVA administered separately for each of the six parameters.

From the TABLE- 2 & 3 we observe the following:

There is a highly significant difference among the vowels for all the parameters studied except on the measures of Relative Average Perturbation (3 point) and Directional Perturbation Factor for Amplitude.

For the Jitter Ratio it was observed that there was a highly significant difference between the vowels /a/, /i/ & /u/. The values for /i/ (12.23) and /u/ (12.54) were found to be significantly higher than /a/ (9.54).

Johnson and Michel (1969) observed a tendency for high vowels to show greater jitter than low vowels. Sorenson and Horii(1983) found significantly more jitter on /i/ than for /a/ & /u/ in females. These findings support the present findings where the values for /i/ & /u/ were found to be significantly higher than for /a/.

Similar results have been obtained by Sai (1992) and Bhuvaneshwari(1992) in 8 year old and 10 year old normal male children respectively.

On the contrary, Venkatesh et.al, (1992) reported that Jitter ratio values are more for /a/ as compared to /i/ and /u/, in adult population.

For the Directional Perturbation Factor (frequency) it was observed that there was a highly significant difference among the vowels /a/, /i/ and /u/. The values of /i/ (67.14) and /u/ (66.91) were found to be significantly higher than /a/(63.63).

Sorenson and Horii (1984) reported that DPF values for /i/ and /a/ are lower when compared to those for /u/. On the contrary in the present study it was observed that values for /i/ and /u/ were significantly higher than those for /a/. A similar finding has been observed by Sai (1992) and Bhuvaneshwari (1992).

Whereas in adults (Venkatesh et.al 1992) it is reported that DPF has lower values for /i/ and /u/ than those for /a/. This is in contrast to the finding of the present study.

For the Relative Average Perturbation (3 point) there was no significant difference found among the vowels /a/, /i/ and /u/.

On the contrary, (Venkatesh et.al 1992) reported that the values of RAP for /i/ and /u/ are lower than that for /a/. However Sai(1992) and Bhuvaneshwari (1992) reported higher values for /i/ and /u/ values as compared to /a/, in 8 year old and 10 year old normal male children respectively.

For Shimmer (dB) it was observed that there was a highly significant difference among the vowels /a/, /i/ and /u/. The values of /i/ (0.24) and /u/ (0.22) were found to be significantly lower than /a/ (0.34).

Horii(1980b) observed /i/ and /u/ values for Shimmer to be lower than that for /a/. This trend was also observed in the present study and reported by Sai (1992) and Bhuvaneshwari (1992) in 8 year old and 10 year old normal male children respectively and in adults by and Venkatesh et.al (1992).

For the Directional Perturbation Factor (for amplitude) there was no significant difference found among the vowels /a/, /i/ and /u/. However, vowel /a/ had a higher value as compared to the other two vowel. Similar findings have been obtained by Sai (1992) and Bhuvaneshwari (1992) in 8 year old and 10 year old normal male children.

On the contrary, Sorenson and Horii(1984) found DPF values for amplitude to be highest for /u/ followed by /a/ and then /i/.

Venkatesh et.al (1992) report DPF (amplitudes) values for the three vowels similar to Sorensen and Horii(1984).

For Amplitude Perturbation Quotient it was observed that there was a highly significant difference among the vowels /a/, /i/ and /u/. The values of /i/ (1.69) and /u/ (1.57) were found to be significantly lower than for /a/ (2.18).

Similar findings were reported by Sai(1992) and Bhuvaneshwari (1992) for 8 year old and 10 year old normal male children respectively and by Venkatesh et.al(1992) in adults.

In summary, generally Frequency Perturbation factors on the whole tend to show higher values for the vowel /u/ and /i/ than for the vowel /a/ whereas Amplitude Perturbation factors tend to show higher values for the vowel/a/ as compared to vowels /u/ and /i/.

TABLE-3 Shows the mean values of 3 parameters of Pitch Perturbation Factors for the thirty 7 year old normal male children and normal adult males.

Pitch Perturbations

Population		Parameter								
		JR			DPF			RAP (3 point)		
		/a/	/i/	/V	/a/	/i/	/u/	/a/	/i/	/u/
7 year old male children	Mean->	9.54	12.23	12.56	63.63	67.14	66.91	0.0063	0,.0100	0.121
Adult males Indian population [Venkatesh et.al 1992]	Mean->	9.17	7.82	8.50	58.28	55.7	56.02	0.0062	0,.0054	0.0058

TABLE-3: Shows the mean values of 3 parameters of Pitch Perturbation Factors for the thirty 7 year old normal male children and normal adult males.

From the TABLE-3 it may be observed that the Jitter ratio, Directional Perturbation Factor (frequency) and Relative Average Perturbation (3 point) measures for the vowels /a/, /i/ and /u/ are larger for the 7 year old normal male children when compared to the adult male population.

This finding indicates the presence of larger perturbation in children. Probably this is because children have incomplete neuromuscular maturation of the laryngeal mechanisms.

Larger perturbations in children could also be attributed to the differences in the laryngeal structures between adults and children.

TABLE-4 Shows the mean values of 3 parameters of Amplitude Perturbation Factors for the thirty 7 year old normal male children and normal adult males.

CH AMD AMPLITUDE PEnTOUDATION IN 8 *YEAR* OLD CIII *DRDS*

TABLE-4: Shows the mean values of 3 parameters of Amplitude Perturbation Factors for the thirty 7 year old normal male children and normal adult males.

From the TABLE-4 it may be observed Shimmer(dB), Directional Perturbation Factor (amplitude) and Amplitude Perturbation Quotient (APQ) measures for the vowels /a/, /i/ and /u/ are larger for the 7 year old normal male children, except for the parameter DPF (amplitude) for the vowel /u/, as compared to the adult male population.

This finding indicates the presence of larger perturbation in children. Probably this is because children have incomplete neuromuscular maturation of the laryngeal mechanism.

Larger perturbations in children could also be attributed to the differences in the laryngeal structures between adults and children.

Table-5 Shows the Directional Perturbation factor for Frequency and Amplitude of 7 year old normal male children of the present study alongwith the data of the 8 year old normal male children [Sai, 1992] and 10 year old normal male children [Bhuvaneshwari, 1992].

Age groups	PARAMETERS					
	DPF(Frequency)			DPF (Amplitude)		
	/ a/	/i/	/u/	/a/	/i/	/u/
7 year	63.63	67.14	66.91	64.25	62.68	59.81
8 year *	63.59	67.90	67.97	63.02	63.93	64.95
10 year **	62.78	68.53	68.43	62.71	66.09	63.24

* Sai (1992)
** Bhuvaneshwari (1992)

TABLE-5: Comparison of DPF (frequency) and DPF (amplitude) across 3 age groups -

To know whether the Directional Perturbation Factor for Frequency and Amplitude varies across the 3 age groups a ANOVA test was administered followed by a DMRT (Duncon's Multiple Range Test).

The results of the ANOVA tests for the DPF (frequency) are summarized in Table-6.

Source	D F	F ratio	S/ns
Ages a	2	1.69	ns
Vowel b	2	80.66	***
Interaction a&b	4	1.82	ns

S/ns - Significant/not significant

*** - highly significant

TABLE-6: Showing results of the ANOVA for the DPF (frequency) across the 3 age groups.

From the Table-6 it may be observed that there is no significant difference in DPF (frequency) across the 3 age groups. In other words the Directional Jitter is same for all the 3 age groups. From this one may infer that there is no need to measure Directional Jitter for each age group ofchildren specifically 7, 8 and 10 year old children.

Table-6 indicates a highly significant difference in Directional Jitter across vowels. This has been discussed earlier in the dissertation.

From the Table-6 one may also observe that there is no interaction between the vowel type and across ages as far as Directional Jitter is concerned.

The results of the ANOVA tests for the DPF (amplitude) are summarized in Table-7.

Source	D F	F ratio	S/ns
Ages a	2	2.45	ns
Vowel b	2	1.68	ns
Interaction a&b	4	2.97	*

S/ns - Significant/not significant

*** - highly significant

TABLE-7: Showing results of the ANOVA for the DPF (amplitude) across the 3 age groups.

From the Table-7 it may be observed that Directional Shimmer does not change across the age groups as in the case of Directional Jitter.

From this we may note that Directional Shimmer for 7, 8 and 10 year old children does not differ.

From the Table-7 we may also observe that directional shimmer does not vary across the vowels also. From this we may infer that it is sufficient to measure directional shimmer for anyone of the vowel for all the three age groups.

SUMMARY AND CONCLUSION

Variations in pitch and amplitude is an essential aspect of normal voice. These normal variations (perturbations) in the voice can be grouped into voluntary perturbations (intonational) and involuntary perturbations (Pitch and Amplitude Perturbations - Jitter and Shimmer respectively).

These perturbations can be measured by various parameters such as Absolute Jitter, Jitter Factor, Jitter Ratio, Shimmer (dB), Direction Perturbation Factors, etc.

Many researchers have studied different Pitch and Amplitude Perturbations measurements in normal and in abnormal voice and Authors generally agree that these measurements can be used for screening and diagnostic purposes of laryngeal disorders. Most of these studies have established norms for Jitter and Shimmer measurements in adult population only. It is well known that children's voice characteristics differ from that of adults because of the continuous neuromuscular maturation they undergo before puberty and the obvious morphological factors. Thus, adult data may not hold good for children in the diagnostic process. Therefore this study was aimed at:

(1) Obtaining norms for the following 6 Pitch and Amplitude Perturbation measurement in thirty 7 year old normal male children.

(a) Jitter Ratio

(b) Directional Perturbation Factor (for frequency)

(c) Relative Average Pertubation (RAP 3 point)

(d) Shimmer (in dB)

(v) Directional Perturbation Factor (for amplitude)

(vi) Amplitude Perturbation Quotient

(2) Comparing the data obtained for 7 year old normal male children with that of adult normals.

(3) Comparing the data obtained for 7 year old normal male children with that of 8 and 10 year old normal male children.

Thirty normal 7 year old male children who had normal E.N.T. findings, normal audiological findings and normal intelligence with no known history of voice problem, vocal abuse or other relevant vocal history were chosen for this study. After a practice session of 5-7 minutes to ensure stable phonation, their voice sample i.e. phonation of vowels /a/, /i/ and /u/ for 5secs each was recorded and most stable phonation of one second duration was analysed for the six chosen parameters. The data obtained was subjected to descriptive statistics such as mean, standard deviation, ANOVA and DMRT to interpret the results and the following conclusions were drawn.

1) Since thirty normal 7 year old normal male children were studied the data obtained for the six parameters can be considered as norms for this age group.

2) It was observed that children have higher Pitch and Amplitude Perturbation measurements as compared to the adults. Thus as per the theoretical expectations the Pitch and Amplitude Perturbation measurements in 7 year old children were found to be different from that of adults.

3) It was observed that Directional Perturbation Factors for frequency and Amplitude did not vary across the ages of 7,8 and 10 year old children.

4) There was a highly significant difference in Directional Shimmer across the vowels /a/, /i/ and /u/. vowel /a/ having the highest value for the parameter.

5) There was no significant difference in Directional Shimmer across the 3 age groups 7, 8, 10 year old male children.

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