ACOUSTIC ANALYSIS OF PROSODY OF MALAYALAM - IN DEAF CHILDREN

Roopa (Jacob)
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MAY 1998

JESUS, MY LORD, MY LIFE, MY ALL,

You used my weaknesses to reveal

Your great sufficiency

I Dedicate my whole self to Thee.

CERTIFICATE

This is to certify that the dissertation entitled, **"ACOUSTIC** ANALYSIS OF PROSODY OF MALAYALAM - IN DEAF **CHILDREN",** *is the bonafide work in part fulfillment for the degree of Master of Science (Speech of Hearing), of the student with* ***Reg. No. M9606.***

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CERTIFICATE

This is to certify that this disseration entitled "ACOUSTIC ANALYSIS OF PROSODY OF MALAYALAM - IN DEAF CHILDREN", *has been prepared under my supervision and guidance.*

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DECLARATION

This dissertation entitled "ACOUSTIC ANALYSIS OF PROSODY OF MALAYALAM - IN DEAF CHILDREN", *is the result of my own study under the guidance of* ***Dr.*** **N.P. Nataraja,** *Professor and Head, Department of Speech Sciences, All India Institute of Speech of Hearing, Mysore, and has not been submitted earlier at any University for any other Diploma or Degree.*

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Ma and Pa, You've been just wonderful. Your unfailing love and prayers sustained me. I love U.

Sonnu Mon, You're an essential part of every stage of my life and memories. We have grown and changed, but brother, You'll always be special to me.

Mahiacca, Ebychacha, though for away, you're close to my heart. I look up to you.

Su, Kana, Elza, Ponti, I'll carry with me pleasant memories of our times together.

Suja, little sunshine, You were all that a little sister would be to me. Thanx.

Neha, Ashley, my loving and faithful prayer partners, I'll remember you.

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Lord Jesus, the more I get to know You, the more I realise what a privilege it is for me to be Your child, to feel Your guidance and love. I rest in the knowledge that You are in control of my life.

CONTENTS

LIST OF TABLES

LIST OF GRAPHS

CHAPTER - I

IHTRODUCTIOH

"Language most showeth a man; speak that I may see thee".

Ben Jonson (1942).

Speech is an integral part of the total personality revealing the speakers environment, social contrasts, and education. There are many indications that language is a vehicle of personality as well as of thought, for when a person speaks, he tells us not only about the world, but also, through both form and content about himself (Fillmore, 1942) Woe to the hearing impaired speaker who is thus judged, for qualities reflected in his speech would provide at best a distorted view of his real self, for the speech of the hearing impaired, (if it exists at all) is a far cry from that of normal hearing individuals.

Hearing validates the speaker's accuracy of expression through speech, for speech is acquired through hearing and normally controlled through hearing. Hearing is the means by which sounds are learned, articulation is directed and inflection is controlled.

The basic units of speech are termed segmental features. Segmental features are thu3 called, because they are discrete in nature. However, in a communication situation, the true meaning of the message, is transmitted not only by what is said, but also by how it is said, by how words are emphasized, and also by the speaker's mood and attitude toward what is said.

The influence of features which involve the way in which segmental3 are said, extends longer than one sound. Hence, they are also termed suprasegmental features (Cruttenden, 1986). Prosody, is an umbrella term and is used to refer to the use and perception of variations in vocal parameters to communicate and understand suprasegmental information. Unlike the segmental elements which can be represented in graphic form through writing, prosody is a feature of spoken communication only. The clearest and most consistent factors in signalling the speakers emotional state were found to be the mean value of the Fo, it's range and the rate of its changes. Duration of production and changes in voice intensity were also described as important parameters. (Scherer 1982, 1986; Siegman 1987).

Acoustic analysis of prosody involves quantifying changes in the three acoustic parameters namely, frequency, intensity and duration, over the time span of the target vocalisation. Interestingly, it is the modulation of only these 3 acoustic parameters that results in simultaneous communication of several suprasegmental messages during discourse, in the form of intonation, stress and duration.

'Intonation' is the rise and fall in fundamental frequency not only as a grammatical signal of completeness and incompleteness, but also as emotional gauges of tension and relaxation. Bolinger, 1972).

Stress expresses itself in the first place by an increase of pressure in the speech mechanism and approximately coincides with the point of greater pressure. (Classe, 1963)

'Duration' of utterance increases for the more important words such as nouns, verbs and modifiers, while those of less importance such as the functor words (prepositions, conjunctions) are passed over lightly. The natural rhythm of speech, depends on these devices and the art of speaking clearly and meaningfully, requires judicious use of each if the prosodic elements to avoid a dull, monotonous type of talking.

With the advent of sophisticated diagnostic procedures, more efficient amplification devices and professionally qualified speech clinicians aiding in communication rehabilitation, hearing impaired individuals are able to attain speech to a large extent. However, while the concrete elements-the various sounds comprising the language, words, the way they should be combined to form sentences (Syntax/grammar), etc. are learnt, a more elusive quality, especially difficult for hearing impaired speakers to attain, is the prosody or suprasegmental aspects of speech, also known as the 'melody of speech' - a sensitive indicator of feelings, meaning, depth, the total emotional, personal, natural or human tinge of speech. This is because, the vocal characteristics of emotional states are manifested by changes in fundamental frequency time and intensity. These are the typical features of hearing impaired speech that differ from those of normal hearing i.e. insufficient and/or excessive variability of pitch, inappropriate (absolute and relative) intensity and inappropriate (absolute and relative) duration. (McGarr and Osberger, 1978); Nickerson, 1975; Stevens, Nickerson and Rollins, 1983). Hence, hearing impaired individuals experience greater difficulty in producing the verbal content of social messages.

Direct mapping of various prosodic contours and their communicative functioning onto the respective control processes, has proven to a difficult task to date. Rapid developments in software designed for acoustic analysis as well as our understanding of the physiology and control of the phonatory system, have resulted in changes in the methodologies involved in addressing this issue. In fact, although prosodic features are used constantly and automatically in communication with others, there have been relatively few studies in this area, particularly in Indian languages and more specifically in Malyalam. It is due to this reason, that the present study was undertaken.

AIM OF THE STUDY:

To study the prosodic features of hearing impaired malayalam speakers who have relatively good speech and to find the prosodic aspects affected in them despite having had speech therapeutic intervention.

NEED FOR THE STUDY:

1. Although described as the first linguistic feature to which the child responds research on prosodic aspects and scanty and can be said to have been neglected in research studies when compared to the attention received by segmental aspects of speech. Hence, a study of prosodic aspects is required to fill in these lacunae.

2) Prosody is inevitably found to be deviant in the hearing impaired even after speech has been acquired. Hence, a need was felt for a study on prosodic deviances.

3) Even among studies on prosody, compared to studies on syllables or words, intonation and stress phenomena in natural discourse 3uch as narration, has been least explored. Hence, a need was felt for a study on prosody during narrative speech among the hearing impaired (The present study used a story narration task).

HYPOTHESIS:

Prosody of the speech of the hearing impaired doesnot differ significantly from that of normal hearing speakers, in terms of

1) Fundamental frequency of speech.
2) Intensity of speech

3) Stress Pattern/Locus
4) Intonation Pattern
5) Rate of speech
6) Amount of pauses - Intra word and Inter word
7) Timing/Rhythm.

METHODOLOGY:

10 normals (5 male and 5 female) hearing and 10 hearing impaired (5 male and 5 female) children aged 3 1/2 to 5 1/2 yrs. were made to narrate the story of the Hare and the Tortoise three times each and the sample which was considered most intelligible was chosen for the analysis. All the subjects were native speakers of Malayalam.

Analysis:

Analysis of the recorded samples was carriedout as follows;

1) Accoustic analysis was done to obtain the speech wave form, fundamental frequency curve and relative intensity curve of each sentence on a time 3cale using a speech interface unit with PC/AT computer having 12 bit. ADC and DAC and speech analysis software (Vaghmi - INTON).

2) Subjective analysis was carried out to find out the mean frequency, intensity and duration of the syllables and also the pauses (inter and intra word) and loci of stress in

each sentence and then it was subjected to statistical analysis.

3) perceptual analysis was also carried out to identify the stress within each sentence.

4) The rate of speech of the hearing impaired and normal hearing speakers was also compared.

IMPLICATIONS OF THE STUDY

(1) A comparison of normal hearing and hearing impaired prosody, will enable a better understanding of prosodic cues such as intonation contours, stress and timing pattern, and how they are deviant in the hearing impaired speakers in general and native speakers of Malayalam language in particular.

(2) A fundamental question in special education of the deaf is how training efforts should be directed to different segmental and suprasegmental aspects in order to ultimately achieve optimal intelligible speech. The present study, will help to highlight aspects which can help in therapeutic remediation of prosodic features in the speech of the hearing impaired.

LIMITATIONS:

1) Only a limited number of subjects have been studied.
2) Speech sample of only children in the age group of 3 1/2 - 5 1/2 years was studied.
3) The story narration task was structured.

CHAPTER - II

REVIEW OF LITERATURE

The development of human civilization is made possible to a great extent, by man's ability to share experience, exchange ideas, and to transmit knowledge from one generation to another. In other words, his ability to communicate with other men.

We use language to communicate with others. Language in the general sense, is any symbolic code-vocal or gestural or any other similar code that is used to express or to understand thoughts, ideas and feeling. As per the chambers 20th century dictionary (1976, Ed.). "Language is an artificial system of signs and symbols, with rules for forming intelligible communications".

Verbal communication (speech),is the fastest and most common form of language used by man. Speech is an integrated function involving the reception of words by the ear or the eye, their interpretation and synthesis as language within the brain and the expression of this language response in further spoken or written words. It includes the whole of this receptive formative and expressive activity. Speech is a system of communication by which thoughts are expressed and understood with acoustic symbols in a given language. For actual speech process, there should be a flow of air from lungs through the larynx and vocal-cords (respiration) the vocal cords should vibrate (Phonation) producing voice and the final product is a result of movement of articulators such as tongue, lips, plate, jaw (articulation) and resonance in the oral cavity. For language processing the child should pass through varying stages to acquire phonology, syntax, semantics of the language he is exposed to. The pattern of vocal expresion in the normally hearing child progresses through a fairly predictable pattern. The first is the stage of reflexive and differential vocalization, seen between the age of (1 to 4 weeks). As soon as the child is born, it cries. It is sign that child has learnt to communicate her presence, although it is at first a reflex action. From then onwards, she starts to express her needs to the parent. Gradually, the mother notices that there are different types of cries within the end of the first or in the early second month. The sensation of hunger, discomfort, pain, etc, are conveyed differentially to the mother. The newborn makes differentiated cries, gutteral "gooing" sounds at about two months of age, single syllable "cooing" at about three months consisting of predominantly vowel sounds, and begins "babbling" or making repetitive strings of sounds (Owens, 1992).

Between 2-6 is the babbling stage. During this stage the child utters many varieties of sounds that are not found in the native language. Some sounds may be repeated and some may not be. At first, only vowels appear but later consonants like /pa/ /ba/ also appear. These sounds random and there is no set pattern for the utterance of these sounds.

At about 6 months the children are found to repeat sounds or sound combinations i.e. lalling is a sign that he/she enjoying hearing his/her own speech and others as well. The child is imitating himself, and because it is appreciated, it is repeated more and more. A deaf child does not pass through this stage because he has no hearing ability to appreciate his own vocal patterns.

At about 9-10 months of age is the stage of echololia. The child starts imitating the speech of other around him. He enjoys imitating the parent, and when the mother or the father repeats it, it is imitated again.

The speech of 3ome handicapped children such as autistics seems to consist of echoalia where they repeat even very difficult sound combinations but without meaning anything. Some children pass through a next stage of producing sentences, which consists of nonsense syllables and words, called vocal play. This vocal play and uttered with normal intonation patterns, but the utterances are not meaningful. In short then, six to seven months of age there is a brief phase where babbling consists of reduplicated syllables, and the infants also focuses on sounds heard in the adult repertoire. At about 9 months variegated babble occurs, that is, patterns of repetition where adjacent and successive syllables are not identical (Owens, 1992). Before recognizable words are uttered the infant produces babbling that reflects the temporal structure of the adult speech pattern. Babbling is thought to provide the essential practice required to develop the links between complex motor commands and plans and auditory representations.

During the period of babbling, infants appear to restrict their practice to only those sound combinations that occur in the language models provided by their main carers. The skills acquired in this phase then form the basis of motor engrains required for rapid speech production as well as the ability to decode speech and later the sound symbol associations needed for reading and writing (Creaghead, Newman and Secord, 1989).

There is some evidence to suggest that cooing is also an important phase in the acquisition of verbal communication skills. Lynch (1995) has shown that cooing patterns in infants as young as two months reflect vocal patterns that are typical of adult speech. This evidence provides support for the notion that infants have the ability to organise their vocal patterns at this early stage.

During the babbling phase infants produce the complete repertoire of physiologically possible sounds. Over a period of weeks they refine their babbling productions to include only those phonemic combinations that are typical of their native language model. An infant living in a bilingual environment will maintain and practice all of the phonemic combinations that are typical of each language they hear. Throughout the babbling phase infants learn to store codes involving auditory perceptual, visual perceptual and motor information for the relationships between speech sounds modelled for them (Repp, 1986). They learn, for example, the complex relationships between the spectral and temporal changes that occur when sounds are uttered as blends and clusters. That is, it is during the babbling phase that children learn about the dynamic nature of speech perception and production as well as patterns of coarticulation (Repp, 1986).

The babbling stage is common even to hard of hearing children. However, because of lack of feedback, of their own speech because of hearing loss they donot progress from this stage very much.

By 12-18 months, the child goes on to utter an appropriate and meaningful first word. Generally, the child uses a bilabial word such as papa or baba. From this age on wards, there is a continuous rapid increase in the child's speech. By this time, the child will have started understanding speech and will quiet when scolded.

At 18 Months the child typically leaves of the beginning and the end of phrases. He makes himself understood through the use of a proper vowel, a medium consonant, and proper vocal infection.

The child's voice is not well controlled and tends to become high-pitched and strained. "He experiments a great deal with voice and pitch, and there is a variety of vocal overflow with little or no phonetic value, such as laugh, sigh, or whisper". The child repeats syllables or words in an easy, unconscious manner.

At 24 months, the child telescopes phrases in his pronunciations; there is usually a beginning consonant, though not necessarily an appropriate one; a final consonant is often present, while medial consonants tend to be slighted.

The voice shows better pitch control than at 18 months. In general, the pitch is lower. There is still some straining, and squeaking is common.

At the age of 30 months, pronunciations of words continue to show telescoping, with the medium consonant frequently slighted. Specific word pronunciations are unstable so that the same word may be pronounced with different vowels and consonants within a few minutes.

At 36 months, pronunciation continues to be characterized by a shattering of word and phrases; medial consonants may be omitted or substituted. Final consonants appear more regularly than 1st 30 months. Substitutions for the sound "th" are frequently made.

The voice is usually well controlled and is in general "of an even, normal loudness".

Thus, the development of speech is a learning process. The child starts with meaningless, haphazard and unintentional vocal utterances, but as he gains experience and maturity with age, his vocalization become meaningful, specific and purposeful. His utterances get established into regular patterns by the positive reaction of his immediate family. The child gradually learns to initiate and echo other persons and thus reasons to produce sounds of the language he and exposed to. As the child begins to gain new experience and forms new ideas, his language ability also increases in terms of gaining the mastery of language and increasing vocabulary and the use of language. A deaf child misses such linguistic experiences, and hence his speech and language are affected. The amount or degree to which it is affected, depends on the age of onset of hearing loss, the degree of hearing loss, whether amplification and training has been provided or not, etc.

Linguists have found, that the code of a spoken language consists of units that are arranged in a lierarchy from small units to large units. The smallest units are the individual sounds, i.e. the vowels and consonants. Speech sounds that differentiate words, are called phonemes, and are, in one sense, the basic sequential segments of speech and thus the features of phonemes are called segmental features. Linguistically, the phoneme is the smallest interchangeable element in a language. Phonemes combine to form syllables and syllables to form words, phrases, sentences.

Intelligible speech is more than a sequence of discrete sounds linked together. The individual sounds must be carefully organised through timing, juncture, stress, and intonation.

These features are termed the suprasegmental features because their domain extends over more than one segment the segmental parameters of verbal communication are referred to as prosody. (Collier 1990).

Prosody has been viewed in the past as decorative ornamentation, functioning to make speech more aesthetically pleasing. Far from being analogous to superficial decoration or ornamentation, prosody functions as the foundation or structural support for the organisation of speech communication (Freeman, 1982).

According to Jusezyk et al (1992) the acoustic stream consists of both segmental and suprasegmental markers that can facilitate interpretation of verbal speech.

The prosodic packages, they suggest, may serve to help the language learner to categorize roughly the acoustic input. In this fashion the range of alternatives that map onto the grammatical target units of a language can be trailed.

Prosody is intrinsic and critical in both perception and production of speech. It embraces all variations of pitch, time and loudness introduced by the speaker in order to emphasize words and syllables and make his/her speech interesting. Although much of the message in speech is conveyed by the 3egmental phonemes, additional information is carried by the prosodic features; stress, rhythm, and Intonation (Anisworth, 1976). The primary prosodic parameters, along which systems of linguistically contrastive features can be plotted, are the psychological attributes of sound described as pitch, loudness and duration, which have a primary (but not an identifying) relationship with the physical dimensions of fundamental frequency, amplitude, and time respectively.

In the historical development of language prosodic features tend to be dominant and to survive changes in the segmental, phonetic constituents. As Pisoni and Sawesch (1975) suggest, "Prosody may serve as the interface between low level segmental information and higher levels of grammatical structure in speech". "Prosody carries direct phonetic cues to certain semantic and grammatical classes. It therefore serves to restrict the search processes whereby contact is made between cognitive representation and acoustic representation. This restrictive role of prosody may take either of two forms, or both. Prosodic information could be additive, that is, it may simply add together with information present at various levels to make the processing, rewarding, and decision making more rapid and more accurate.

In general, current investigations suggest two interrelated ways in which Prosody may function: (i) as a "chunking" or "parsing" device for dividing the incoming flow of speech into coherent auditory structures suitable for further processing and (ii) as a predictive device allowing the listener to anticipate the arrival of potentially important speech material. In either or both of these ways, prosodic information would be potentially valuable in allocating processing capacity and circumventing previously discussed capacity limitations.

Investigations have provided evidence that prosodic information cut across most, if not all, levels of perceptual analysis influencing segmental analysis and Syntactic analysis (Lieberman, 1967; Bolinger, 1972; Other research supports the cue or prosodic information in grammatical analysis (Cooper and Soren 1977) in identifying and delimiting elements of longer discourse level, and speech sequences, such as paragraphs (Lehiste, 1975); in selective attending to one voice among many and interpreting a speaker's communicative intent (Haddingkock and Studdard Kennedy, 1974). Still other investigators have emphasized research findings which suggest that the production of prosodic features is rooted in, and may provide information about neurophysiological organisation and physiological anatomical constraints Lieberman, 1977; Allen, 1975).

There is evidence that early communication is extremely supra3egmental in nature. Gerken (1994) reports that infants as young as eight months of age exhibit in their babbling the rules of prosodic patterns of their native language. In addition, infants as young as six months of age are able to distinguish between English and Norwegian word lists that have been low-pass filtered. Gerken also reports findings that infants at six months are sensitive to clause boundaries and at nine months can distinguish phrase boundaries. At nine months, they prefer to listen to stress patterns that reflect their native language (Gerken, 1994). The infant varies intonation patterns to express physiological and emotional needs. (Lewis, 1951, Lenneberg, 1967). Crystal (1973) suggests that infants respond to suprasegmentals at an early age, possibly at the expense of other linguistic features. He said that 6-7 months is the most likely period for emergence of nonsegmental aspects of language. From 9-12 months, a wide range of non segmental contrasts is developed (Crystal, 1975) and with increasing age, prosodic patterns become more readily influenced by factors such as vocabulary and phonemic structure.

In the absence of hearing the child is deprived of the required feedback information both of himself and of others, so essential for the development of prosody. Hearing-impairment has a marked effect on a child's ability to acquire speech. The orderly and seemingly natural development of speech language and comunication is interfered with by presence of hearing loss. The normal hearing child is exposed to sounds from the very beginning itself. By continual auditory stimulation by the constant feeding of speech into his ears, by unceasing encouragement from his mother, by hours and hours of practice a normal child attains speech. The task is more difficult for the child born deaf and yet often enough the deaf child is deprived of these very means which alone make speech possible. Thus hearing controls speech and without hearing speech fails.

The normally hearing child obtains skills in parsing connected speech signal exaggerated and synchronized prosodic cues from caregivers (Jusezyk et al., 1992), so the hearing impaired child may require assistance in acquiring this information. Differences between the normally hearing and the hearing impaired infant's prelinguistic vocalisation patterns are detectable as early as six weeks of age (Maskarinec, Cairns, Butterfield and Weamer, 1981). Normally hearing children have been reported as making "speech-like" sounds at this early stage whereas hearing impaired infants do not. The most noticeable difference occurs at the early babbling phase around six months of age, when the productions of the hearing impaired infant are noticeably reduced in comparison to the normally hearing infant. The range of sounds included in the babbling phase is also reduced for the hearing impaired child, especially after eight months of age (Stoel-Gammon and Otomo, 1986). The consequence of reduced auditory feedback is therefore, a reduction in the amount of practice that the infant engages in. In addition, the hearing impaired child's spontaneous sound productions do not reach the stage where they become focused on the sound combinations that are typical of the native language model provided in their environment (Stoel-Gammon and Otomo, 1986).

The acoustic cues for prosodic features which have received the most extensive attention are Fundamental frequency and it's variations (intonation), intensity, and temporal spacing of acoustic events.

1. FUNDAMENTAL FREQUENCY PATTERNS.

The difficulties that the deaf speaker has with frequency pattern are of 2 general types:

a) In appropriate average fundamental frequency (pitch)
b) Improper intonation.

2. FUNDAMENTAL FREQUENCY/PITCH

The Fundamental frequency is often loosely called the pitch. The fundamental frequency of voiced speech sounds, varies considerably in the speech of a given speakers and the average or characteristic Fundamental frequency varies over speakers. Average Fundamental frequency decreases with increasing age until adulthood for both males and females (Fairbanks, 1940; Usha, 1979). The fundamental frequency varies in the speech of an average speaker over a range of

One to one and a half octaves (Fairbanks, 1940). This variation is used to indicate stressed and unstressed vowels, to add emphasis to what is being" said and to carry information about the structure and meaning of a sentence. Linguistic and semantic information is carried by pitch in several ways. A falling pitch is used, to signal the end of the final stressed vowel in a declarative sentence. At a major syntactic break within a sentence, such a fall is followed by a rise in pitch to indicate that the sentence is to continue. For certain types of questions, a pitch rise occurs in the final stressed syllable. Sentences that are ambiguous when printed can be spoken in an unambiguous way, partly because of the intonation pattern that is imposed on the words. Also, messages beyond the words, sometime subtle sometimes poignant can be conveyed by the way the utterance is inflected (Nickerson, 1975).

FUNDAMENTAL FREQUENCY ABBERATIONS IN THE HEARING-IMPAIRED

Among the most noticeable speech disorders of the hearing impaired are those involving fundamental frequency (Fundamental frequency). Voelkar (1963), Green (1956), and Hood (1966) found that the voices of children who made little or no use of their residual audition, had intonation spanning less than half the normal range of 8-12 semitones.

Pitch has been described by Boothroyd, 1969 as a particular by difficult property of speech for deaf children to learn to control. One possible reason for the difficulty is that deaf children may lack a conceptual appreciation of what pitch is. (Anderson, 1960; Martony, 1968). If there is a problem with a hearing-imapired speaker's average fundamental frequency, more often the voice pitch is characterized as too high rather than too low (Angelocci et al., 1964; Boone, 1966; Martony, 1968). Some differences in average Fundamental frequency have been found as a function of the age or sex of the hearing-impaired speakers.

Monsen (1979) found that the types of contours appeared to be an important characteristic separating the better from poorer hearing impaired speaker. While studying the manner in which fundamental frequency changes over time, using a spectrographic technique, Monsen (1979) observed four types of fundamental frequency countour in the speech of the hearing impaired children of 3-6 years age. They are:

a) A falling contour, characterised by a smooth decline in Fo at an average rate greater than 10 Hz per 100 msec.

b) A short falling contour, occuring on words of short duration. The Fo change may be more than 10 Hz per 100 Msec. but the total change may be small.

c) A falling flat contour, characterised by a rapid change in frequency at the beginning of a word, followed by a relatively unchanging flat portion.

d) A changing contour, characterised by a change in frequency, the duration of which appears uncontrolled, and extends over relatively large segments.

Boone (1966) found a higher average Fundamental frequency for 17-18 year old males than females. Gold (1980) found that mean Fundamental frequency of deaf people's voices is higher than that of hearing speakers of similar years. Osberger (1981) found that the difference in Fundamental frequency between hearing and hearing-impaired speakers in the 13-15 year age range was greater for females than for males. (Fig. 1). Bush (1981) observed excessive segmental variations in Fundamental frequency as those in the Osberger (1981) study. Age-related factors sucha s laryngeal growth accompanied by adolescent voice change or similarities in spech training were suggested by Bush as reasons for the problems of the females in controlling Fundamental frequency.

Thus the fundamental frequency of the hearing impaired and found to be higher, more 30 in the female. Also there are excessive segmental variation in fundamental frequency.

B. INTONATION:

"Intonation is the salt of an utterance. With out it, a statement can be often understood, but the messge is tasteless, colourless. Incorrect uses of it can lead to embarrasing ambiguities". (Delattre, 1972). Words have basic intrinsic meanings; these lexical meanings are the ones found in the dictionary. The intonation meaning is quite the opposite. Rather than contributing to the intrinsic meaning of a word, it is merely a shade of meaning added to or superimposed upon that intrinsic lexical meaning, according

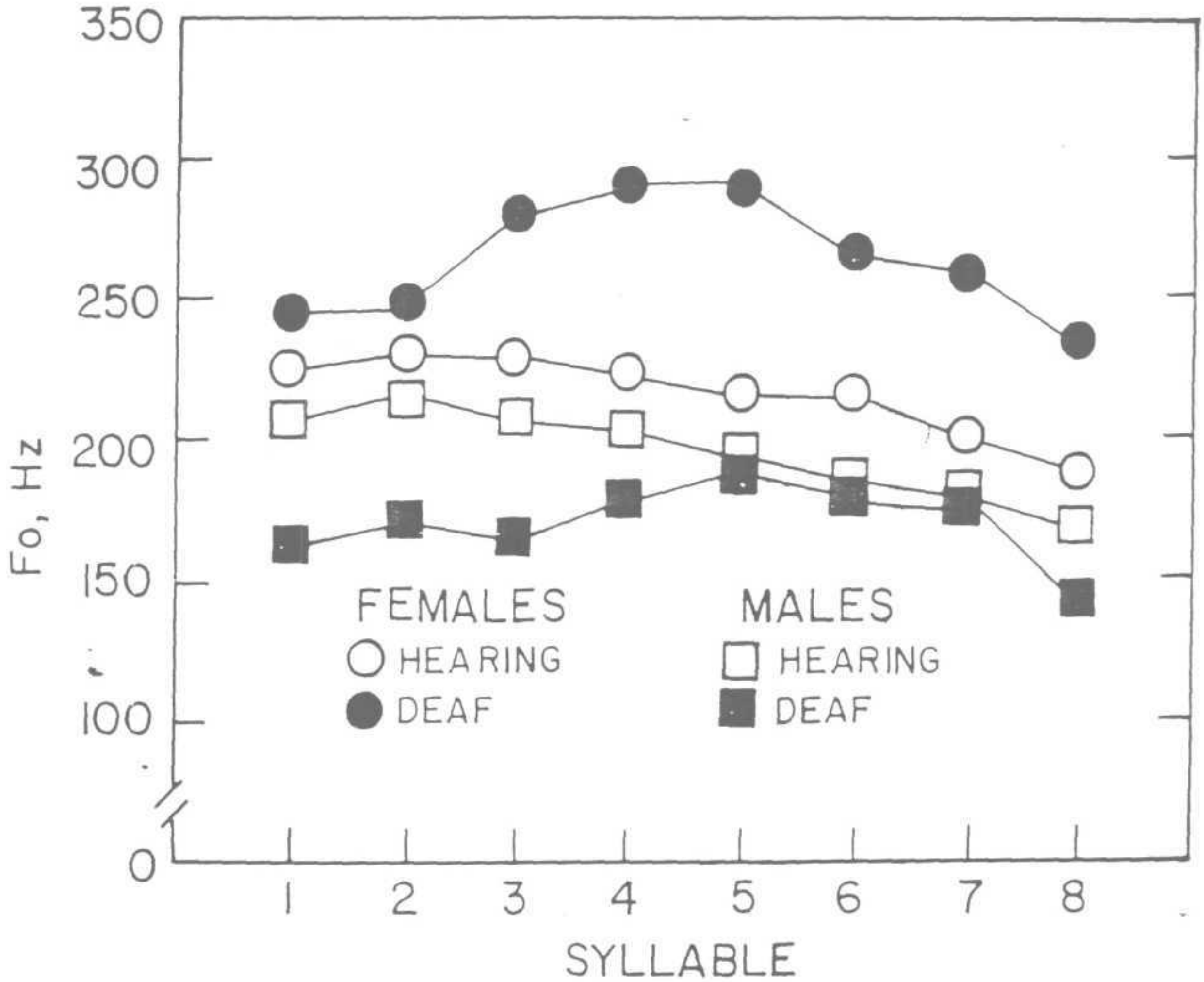

Figure 3. Fundamental frequency values in Hz, measured at the center of the vowel in each syllable in the sentence "I like happy movies better" for groups of normal-hearing and profoundly hearing-impaired males and females.

to the attitude of the speaker. In actual speech, the speaker is often more interested in the speaker's attitude, than in his words - ie; whether a sentence is spoken with a smile or with a sneer according to Pike, (1945).

Some researchers like Bolinger(1972) consider intonation as only a peripheral part of oral communication. According to Bolinger (1972), "Intonation is not as central to communication as some of the other traits of language. If it were so, we could not understand someone who speaks in a monotone". "This is like saying that voicing is not crucial to communication because we can understand whispered speech". (Ling, 1971).

Among the suprasegmentals, intonation is an inclusive term that refers to variations in pitch as a function of time. Fairbanks (1940) used the term intonation to include both inflection and pitch shift. He used inflection to identify the pitch change within a single phonation and pitch shift to identify change in pitch from the end of one phonation to the beginning of the next phonation.

Lehiste (1970) used the term intonation as linguistically significant functioning of fundamental frequency at the sentence level. Contrastive function of fundamental frequency is called 'tone' at the word level. She distinguished between lexical tone, grammatical tone and morphemic tone. Lexical tone is found in languages in which contrastive tone is associated with differences in the meanings of roots and steins (independent of stem formatives). Among such languages are Chinese and Slovene. The term 'grammatical tone' is applied to instances in which a difference in tone signals a difference in grammatical function without changing the lexical meaning or overt morphological structure. The term 'morphemic tone' is used in instances in which the tone on a root is predictable from the presence of a suffix morpheme, which need not carry the tone overtly.

Most traditional perceptually based phonetic theories (Armstrong and Ward (1926), Pike (1945), Trager & Smith (1951) and many instrumental studies (Lieberman (1967), Hadding-Koch (1961), Vanderslice and Ladefoged (1972), Atkinson (1973), Tseng (1981), Landahl (1982) agree in so far as a falling of fundamental frequency and amplitude contour forms the terminal part of the breath group, that signals the end of a declarative sentence/phrase in most human languages (Lieberman (1967). The falling of the frequency and amplitude contour reflects the biological and vegetative constraints of respiration.

Bolinger (1975) states that there are three features of intonation which have similar uses in all languages. They are:

1. **Range:** The range conveys emotions. When we are excited our voice extends its pitch upwards. When we are depressed, we speak almost in a monotone.

2. Direction: It is usually connected with pause

3. Relative height: It is associated with the importance given to particular word or words in a sentence. Intonation also plays a useful role in the determination of voice quality, (Brown, strong, and Rencker, 1973) and in recall of verbal materials (Leonard 1973),)

It has long been realized that within the prosodic contrasts of English, some features are more noticeable and seem to carry more semantic weight than others. This awareness is reflected very early in the development of prosodic though its formulation has been relatively recent. Butler in the 17th century noticed the importance of making a main distinction between rising and falling intonations.

Sweet (1878) distinguished eight tones in all, some being more fundamental than others. They are: level, high rising, low rising, high falling, low falling, compound rising, compound falling and more emphatic.

Palmer (1922) distinguished four basic types of tones falling, high rising, falling rising and low rising which are almost invariably intensified and hence are considered normal. He also described intensified falling tone and two kinds of tonal sequence.

1) Co-ordinating (\\ // ) where the tone groups are identical.

2) Subordination ) where the tone groups are dissimilar.

Armstrong and Ward (1926) based their dichotomy of falling and rising tones referring to the general shape of intonation contours centered on a special nuclear type. Heffner (1949) distinguished between level, high rising, high falling, compound rising and compound falling as being tonal contrasts. Nijland (1951) put forth five different intonation curves - Monotone - horizontal (—), Convexe - descendant (⌒), Concave - d e s c e n((◡),ɔ n c a v e ascendant (◡), and Convex - ascendant (⌒). Lee (1953) distinguished between different types of tone sequences.

1. On pairs of Questions (\ /).
2. On longer sequence of Questions (/// \ or ///) and
3. On two co-ordinated sentences varying inonly one predicate word (/\).

McCarthy (1956) distinguished between the following types of tones - Rise-fall, Fall-rise, Rise-fall-rise, fall-rise-fall with high and low varieties of each. Hultzen (1957, 1964) divided nuclei into two groups on whether they have a low (closed) ending or an open ending. Mitchell (1957) specified level, high rising, high falling and compound rising types of tones. Kingdon (1958a) made a distinction between high and low, normal and emphatic tones and then lists rising, falling, falling rising (divided and undivided types), rising falling (1, 2 and 3 syllable types), rising falling rising (divided and undivided types) and level tone (though the latter is not nuclear). Schubiger (1958) identified exocentric (subordinate) and endocentric types of tone sequences. The specific sequences she mentions are - rising+falling (⁄ + \ ), compound rising+falling (V + \ ), falling+falling (\ + \ ), rising+rising (⁄ + ⁄), compound rising+riaing (V + ⁄), and falling+rising (\ + ⁄). She also distinguishes between different types of tone sequences occurring on enumerations (⁄⁄⁄ \ ), the more colloquial (\\\\ ), sequences which are susceptible on continuation (⁄⁄⁄⁄), patterns which lays emphasis cm the penult (\\\ ^ \ ), and on alternatives (⁄ \ and ⁄⁄).

Trim (1959) made a major distinction between formally independent major tone groups and minor tone groups which are characterized as dependant and non-final. He placed importance towards phonological criteria rather than a grammatical approach to define major tone groups. O'Connor and Arnold (1961) recognize low and high falls and rises, rise-fall, fall-rise and a compound 'fall+rise' though the latter is considered a conflation of two simple tones. In total they distinguish six tone types and ten types of tone groups. Intonation was analysed by Halliday (1966) as a complex of three systemic variables:

1. Tonality (the division of an utterance into tone groups and the placement of tone group boundaries)
2. Tonicity (the placement of the tonic syllable and foot within the tone group and the consequent division of the group into tonic and pre-tonic elements of structure).

3. Tone (which is divided into primary and secondary-tone).

He recognized fall, rise, 'sharp' fall-rise, fall-rise, low-rise, rise-fall, fall+low rise, and rise-fall-low-rise as primary tones. He distinguishes between even (level, falling, rising), uneven (low spiky) and suspended (listing), high (level, falling, rising) and low (level, rising), mid (level) and low (level) sub types of secondary tone. he believed that tonality, the division of an utterance into tone groups not fusion of tones, is at present the first kind of choice important for intonation. He, however believed that further research will demonstrate the existence of tone group sequences, which would require at least one intermediate stage between an utterance and a tone group.

In a study by Quirk and Crystal (1966), a major division of nuclear tones into two types was done -

1. **Falling** : Comprising simple, complex and compound tones, the final direction of the pitch movement being downward.
2. **Rising** : Comprising simply, complex and compound tones, the final direction of the pitch movement being upward.

Aquisition Of Intonation In Children has been studied by many. There is 3ome evidence that early communication is essentially suprasegmental in nature (Lewis,1951; Lenneberg, 1967). Intonation patterns are aquired by children even before the actual acquisition of speech sound.In the very first few months of life, during the babbling stage and indeed during the very first minutes of life, children employ 'meaningful' intonational signals. The infant varies intonation patterns to express physiological and emotional needs. At the age of 6 -7 months, the child begins to imitate the intonation of the adults talking to him (Nakazima, 1962). At about the 3ame age, most babbles of children, are produced with a falling declarative intonation, but then the child begins producing both rising and falling, questioning intonation patterns (Tonkova Yompolstaya 1969).

Lewis (1936) noted three stages in the development of intonation in language.

1. At an early age, the child shows discrimination in a broad way, between different patterns of expression in intonation.
2. Then, the total pattern- the phonetic form together with the intonational i.e dominates the child's response.
3. Later The phonetic pattern becomes the dominant feature in evoking the specific response. But while the function of the intonation pattern may be considerably subordinated, it certainly does not vanish.

Lieberman (1967) showed that the basic pitch of the babbling of two children at ten and thirteen months of age shifted towards the pitch of the adult speaking to them.

When the father was speaking with the child, the pitch of the babbling was lowered to nearer that of the father; when the mother spoke to the child, the babbling occured at a somewhat higher pitch, in keeping with the higher voice of the mother.

Speech perception studies have indicated clearly that both prosodic and segmental aspects develp as early as six weeks in children (Morse (1972), Mehler et al (1978), Nooteboom (1978), Kessen, Levine & Wendrich (1979).

Infants have been found to discriminate between rising and falling patterns of intonation between 1.5 & 2 months (Morse (1972). By the age of eight months children could discriminate between a syllable pronounced with a rising intonation and the same syllable said with a falling intonation (Morse (1972). Dore (1973), has reported that children learn and produce intonation patterns of the input language during the first year of life. Crystal (1973) suggested that infants respond to suprasegmentals at an early age, possibly at the expense of other linguistic features. He noted that 6-7 months is the most likely period for the emergence of non-segmental aspects of language.

With increasing age, prosodic patterns become more influenced by factors as phoneme structure and vocabulary. By 18 month most normal children use intonation patterns typically produced by adult speakers in their language environment (Menyuk (1972) and by 2 years of age have less than 3% error in imitating simple rising and falling inflections (Kressin, Marquardt and Asp (1976), Koike (1977), Koike & Asp (1977) found that 5 year olds performed significantly better than 3 year olds on a more complex supra segmental task.

Sandner (1981) demonstrated a three month old infant imitating his German speaking mother during a five minute conversation. The infant in sandner's study appeared to regulate subglottic pressure and imitate intonation patterns as soon as his anatomy developed to the point where he could regulate subglottic pressure. A more recent investigation on early imitation was done Rabson et al (1982). Acoustic analysis of a conversation between a Japanese speaking mother and her six week old son, showed the infant imitating the absolute fundamental frequency and the shape of the mother's intonation contour, the duration being lesser, however.

Landahl (1982) reported that the fundamental frequency contours of one word utterances in children and quite similar to those seen in adults. Based on Menn' s (1976 a) and Halliday's (1975) work on tonal contrasts a tentative analysis of tonal contrast development was put forth by Crystal (1986).

1. Initially the child uses only falling patterns.
2. The first contrast that is developed is between falling and level tones.

3. The Second contrast is between falling and high rising tones.
4. The next contrast is between falling and high falling tones (as in contexts of surprise, recognition, insistence etc.,).
5. A contrast between rising and high rising tones follows.
6. The next contrast is between falling and high rising-falling tones; the latter being used in emphatic contexts.
7. Next appears a contrast between rising and falling-rising tones, the latter especially seen in warning contexts, presumably the 'be careful' pattern in adults.
8. Among later contrasts to appear is that between high and low rising - falling tones, especially in play contexts.

However Fernald (1978), Stern (1983) believed that mother's make adjustments to the prosody of their speech as soon as their babies are born. Stern (1983) studied prosodic pattern in mothers interaction with their children at birth and aged four, twelve and twenty four months examining the variations in pitch (terminal contour change, transitional change between utterances, overall utterance range and highest utterance level timing and rhythm. They found that lengthened pauses were most noticeable at birth, exaggerated pitch contours and higher levels at four months and longer utterance durations at two years. They suggested the need to consider adult prosody to children in terms of a series of phases of development, arguing that during a particular phase of interaction, a mother increases the use of a subset of features and decreases use of others.

A sentence with a specific emotion can be expresed with more that one type intonation pattern, and a ingle intonation pattern may be used express sentence with differen emotion.

Nataraja (1982) comapared the intonation contour in four Indian languages (Kannada, Tamil, Gujarathi and Hindi) under five emotional conditions a) Anger, b) Joy c) Jealousy d) Neutral e) Mercy.

He concluded that "same intonation contour may be used to express different emotional conditions and further, the same patterns/contours are seen across the languages used". There seems to be common or 'universal' intonation contours across the languages studied.

Rathna, Nataraja and George Samuel (1976), conducted an experiment to study the identification of intonation with reference to context. They have concluded that the listeners were not able to identify the correct pair of intonation sentence and context sentence. It was also concluded that it is possible to use a similar kind of intonation pattern in different contexts in the Kannada language. Thus, the reference contexts may become important in identifying the intonation.

Manjula (1979) studied intonation in Kannada under 9 emotional conditions using 36 sentences. She has concluded that "The sentence in Kannada with emotion are expressed with a final in the intonation pattern".

Nataraja, (1981) studied the intonation patterns in four Indian languages (Kannada,, Hindi, Tamil and Gujarati) under five emotional conditions i.e joy, jealousy, neutral, anger and mercy. There was no difference between instrumental and subjective analysis. When the comparison of intonation contours on different emotions within each language was made, the following conclusions were drawn.

1. A comparison of analysis of intonation contours of Kannada language showed that five different contours have been use by the subject. However 3 of te sentences with anger, jealousy and neutral showed lowering of fundamental frequency at the end whereas other conditions, mercy and joy showed an increase in fundamental frequency at the end of the sentence. These results are in agreement with conclusions drawn by Manjula (1979).

2. Intonation contours of sentence spoken in Gujarathi showed a gemeral lowering of fudamental frequency by the end of the sentences. The subject had used almost same intonation pattern/contour different emotional conditions. It may be possible to express different emotions using the same intonation contours as in Kannada, as reported by Manjula (1979).

3. In Tamil sentences, the same intonation contours has been used to express Anger and Mercy, whereas different contours have been in other three sentences. However, there was a general lowering of fundamental frequency towards the end of the sentences.

4. To express anger, neutral, and mercy in Hindi, the same intonation pattern has been used. To express jealousy and neutral, two different patterns have been used. It was found that there was an increase in fundamental frequency towards the end of the sentences.

When the comparison of intonation contours across the languages under different emotional conditions were made, it showed lowering of fundamental frequeny at the end of the sentence under anger in all the languages except in Hindi where there was a rise from low to mid. Under joy condition all the subjets showed a lowering of fundamental frequency except for the subject speaking Kannada, who showed an increase from mid to high. In all the four languages there was a lowering of fundamental frequency at the end of the sentence under the conditions of jealousy. Under neutral condition there was a lowering of fundamental frequency in Kannada and Hindi whereas there was a rise in two other languages.

Rathna et al. , (1982) did a study to find the influence of intonation patterns of part sentences on the identification of the contexts in their part sentences are spoken. The results showed that it was not possible for the subjects to identify the correct contexts sentences when either only part sentence was spoken on part sentence and context sentence was given together.

Nandini (1985) studied prosodic aspects in Kannada and found that in Kannada, different intonation patterns aare used in expressing different types of sentences. Terminal contours are important in determining the type of sentences of the terminal contours can be used to identify different types of sentences. Percepeption of pith variations depend of Fo variation and pitch is important for the perception of intonation. Intensiyty variations do not show difference between different types of sentences. Inton permits the identification of emotion type of sent even when the context sentences aren't present.

Chandra Shekar (1985) studied prosodic aspects in Hindi and found that Hindi speakers use different inton patterns to express different emotions. The intensity variation doesn't seem to be related to the emotions expressed. Perception of pitch variation depends on the Fo variation.

2. Intonation Patterns in the Hearing Impaired:

Reference is made, even in the very easily literature, to the difficulties that hearing-impaired speakers experience in controlling this aspect of speech. Haycock (1933), Rawlings (1935), Russell (1929), Scripture (1913), and Story (1917) have described the speech of cogenitally deaf persons as "monotonous" and "devoid of melody". Later investigations showed that hearing-impaired speakers did produce pitch variations, but the average range was more reduced than those of speakers with normal hearing (Green, 1956; Hood, 1966; Voelker, 1935) and hence it sounded monotonous. Monotonous speech may also be due to abnormalities in the shape of pitch contours. Each syllable may carry a similar pitch contour. A subjective sense of monotony may therefore arise from a repetitive use of a single contour. (Nickerson, 1975).

Some hearing-impaired speakers may demonstrate an intonation problem in the form of excessive and inappropriate changes in fundamental frequency. These speakers may raise or lower fundamental frequency by 100 Hz or more within the same utterance. Often, after a sharp rise in fundamental frequency, the hearing-impaired speaker loses all phonatory control and there is a complete cessation of phonation (Monsen, 1979; Smith, 1975; Stevens et al., 1978). A terminal pitch rise - such as that occuring at the end of some questions may be even more difficult for a deaf child to produce than a terminal fall (Phillips, Remillard, Bass and Pronovost, 1968).

There have been few attempts to arrive at a quantitative classification of intonation contours produced by hearing-impaired children. Monsen (1979) has described the following four types of contours that he found to occur in the production of CV syllables by 3- to 6-year-old hearing-impaired children:

(1) A falling contour, characterized by a smooth decline in Fundamental frequency at an average rate greater than 10 Hz per 100 msec; (2) a short falling contour, occuring on words of short duration the Fundamental frequency fall may be more than 10 H z per 100 msec but the total change may be small; (3) a falling-flat contour, characterized by a rapid change in frequency at the beginning of a word, followed by a relatively unchanging, flat portion; (4) a changing contour, characterised by a change in frequency, the duration of which appear uncontrolled, and extends over relatively large segments. Monsen's (1979) classification scheme represents a substantial step forward in describing the intonation patterns of the hering impaired. It remains to be determined if such a classification scheme can be used to describe objectively the intonation patterns of entire sentences as well as isolated syllables. One factor that strongly inflences fundamental frequency changes in the degree of stress placed on syllable in a breath group. Typically,s tressed syllables are spoken with a higher Fundamental frequency than unstressed syllable (Fry, 1955). Thus, the contour consists of Peaks (rises) and valleys (falls) in fundamental frequency that correspond and to the stressed and unstressed syllable pattern of the sentence. This

pattern is distorted in the speech of the hearing impaired.

Frank, Bergman and Tobin (1987) described the difficulties encountered by children with hearing impairment in producing orally read sentences with correct intonation contour. According to their findings, during attempts to form sentences, some of the children read each of the words seperataly as if the words comprised a list of unrelated vocabulary. The children failed to employ a look ahead strategy that include planing the production of the whole sentence while considering the intonation as well. Other children with similar hearing losses succeeded in producing the sentences with the appropriate intonation contours.

Rubin - Spitz and Me Garr (1990) Showed that hearing impaired children in their study were able to produce declarative sentences correctly with a falling contour. However, they did not produce non-declarative sentences with a rising contour. All sentences were produced with a terminal fall.

The study by Most and Frank (1991), Indicating that severely and profoundly hearing impaired children are able to perceive and produce intonation contours. These results corroborate the findings of studies by Engen et al. 1983 & Most 1985.

STRESS

Amplitude modulation is manifested in language by what is most commonly termed, stress (Allen 1975). According to Sweet (1878) "stress is the comparative force with which the separate syllables of a sound group are pronounced". Classe (1936) opines that "stress is an impulse (primarily of a psychological nature) which expresses itself in the first place by an increase of pressure in the speech mechanism and approximately coincides with the point of greatest pressure".

Writers on phonetics and linguistics generally use 'stress[1] to denote either 'The degree of force' with which a syllable is uttered (Jones 1949), or 'degree of Ioudnes3' (Block and Trager, 1942), but it is often implied or explicitly stated that these two things are completely correlated; Bloomfield (1933), for ex. says that the stress[1] consists in speaking one of these syllables louder than the other or other[1].

Stress may be defined as the perception of some linguistic units as emphasized or prominent in contrast to surrounding units (Freeman 1982). Unit3 of phonological, syllable, word, phrase, clause sentences or paragraph length may be stressed in contrast to surrounding speech. Bolinger (1958) has said that "stress is the perceived prominence imposed within utterances". Thus, stress involves the rendering of one element more prominent than other elements within a unit and is achieved primarily by alterations of duration, loudness and or pitch (Allen and Hawkins, 1978, 1980; Fry, 1955; Lieberman, 1967; Lieberman, Harris and Sawashiraa, 1970).

In traditional phonetics, stress has been frequently divided into dynamic or expiratory stress and musical or melodic stress. This assumption seems to have been based on a belief that stress and pitch are independent of each other.

Jones (1950, 1962) listed level stress, crescendo stress, diminuendo stress and crescendo-dimineundo stress. All these four stress have been claimed to exist in serbo-croatian (Fry and Kostic, 1939; Trager, 1940).

Stress may function linguistically at word level and sentence level. Word level stress or phonemic stress presupposes that the domain of stress is a word, and that the definition of a word does not depend on a criterion involving stress (Lehiste, 1970). The minimum size of the unit of stress placement is the syllable, however stressed and unstressed monosyllabic words can be distinguished only within a larger utterance. Thus, the minimal unit of contrastive stress placement is a sequence of two syllables.

If the placement of stress on one of the syllables of the utterance is not predictable by morphological, lexical or syntactic criteria, it is 3aid that stress occupies an independent position within the phonology of the language. This kind of linguistically significant stress is termed as

phonemic or free stress. (Lehiste, 1970). Languages in which stress functions to distinguish between otherwise identical words include Russian and English. In English there are very few pairs of words that are distinguished by nothing except the place of stress. Here, stress is used contrastively. For free stress shifting the stress changes the word into another word and not into a non word. On the other hand, in a number of languages the place of stress on a certain syllable is fixed and is determined with reference to the word. The position of stress identifies the word as a phonological unit (Jakobson, 1931). Placing the stress on a different syllable changes the word into a non word. In languages with such bound stress, there is no opposition between stressed and unstressed syllables within word-level phonology.

Bound stress may occur on the first syllable of a word, as in Czech or Hungarian; on the last syllable as in French or Turkish, or on the penultimate syllable as in polish. The placement of bound stress may also follow more complicated rules as in Latin where stress is placed on the penultimate syllable, if long and on the third syllable from the end, if the penultimate syllable is short (Jakobson, 1931). Shifting the bound stress results in mispronounciation.

An intermediate type between phonemic stress and bound stress is morphological stress (Jakobson, 1931). In languages with morphological stress, the position of stress is fixed

phonemic or free stress. (Lehiste, 1970). Languages in which stress functions to distinguish between otherwise identical words include Russian and English. In English there are very few pairs of words that are distinguished by nothing except the place of stress. Here, stress is used contrastively. For free stress shifting the stress changes the word into another word and not into a non word. On the other hand, in a number of languages the place of stress on a certain syllable is fixed and is determined with reference to the word. The position of stress identifies the word as a phonological unit (Jakobson, 1931). Placing **the** stress on a different syllable changes the word into a non word. In languages with such bound stress, there is no opposition between stressed and unstressed syllables within word-level phonology.

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An intermediate type between phonemic stress and bound stress is morphological stress (Jakobson, 1931). In languages with morphological stress, the position of stress is fixed with regard to a given morpheme but not with regard to word boundaries. Morphological stress may differentiate between compound words but not between individual morphemes. This kind of stress distinguishes between the two German verbs Ubersetzen, "to tranlate" and ubersetzen "to take across". Weinrich (1954) calls this type of stress constructive stress.

In Tamil, the placement of stress is not fixed (Raghavendra, and Leonard, 1989). When stress functions at the sentence level, it does not change the meaning of any lexical item but it increases the relative prominence of one of the lexical items. There are three types of stress (Bierwisch, 1966). Primary stress (non-emphatic stress), contrastive stress and emphatic stress. Each sentence has automatically a primary stress. Here, in a segment of the sentence what the speaker wants the hearer to attend to is stressed. Contrastive stress occurs in sequences of sentences with parallel constituents that are filled with different morphemes. In other words, contrastive stress is used to distinguish a particular morpheme from other morpheme that may occur in the same position.

Emphatic stress is used to distinguish a sentence from its negation. Occasionally, it may be phonetically indistinguishable from contrastive stress; but thera are instances and languages in which the two are different.

Bierwisch (1966) explains that in German emphasis is accompanied by a greater degree of reduction of other stresses in the sentence than is found in the case of contrastive stress.

Prosodic features including intonation, rhythm and stress fulfil important functions in speech perception and production. Perceptually, prosodic information assists the listener in segmenting the flow of speech by contouring words. Syntactically, prosodic features help differentiate among different sentence types through different patterns. Lexically, prosodic features aid in differentiating grammatical categories, such as verbs and nouns. In addition, prosodic features also relate to specific pragmatic functions. For eg. contrastive stress is used to distinguish between topic and comment (Chafe, 1970). Linguistic stress is a feature of speech perceived by the listener which involves complex interactions of suprasegmental elements. Bolinger (1972) has stated that the distribution of stressed elements in speech functions for semantic and emotional highlighting by drawing the listener's attention to them. Bates (1976) added that it is used to distinguish new and old information in discourse. The new information is generally stressed while the old information is not. Baltaxe (1984) explained that linguistic stress functions to set off elements which carry a heavier information load and which the speaker wishes to place into focus. Thus, stress can be used simply to give special emphasis to a word or to contrast one word with another. In production, thi3 would allow the speaker to speak rapidly and carelessly slur on unstressed elements concentrating on careful articulation on only critical elements. Another major function of stress is to indicate the syntactic relationships between words or parts of word. There are many noun-verb oppositions in English. For eg. "an overflow", "to overflow" -in this pair the noun has the stress on the first syllable, the verb has it on the last.

The placement of stress indicates the syntactic function of the word. Similar oppositions occur in cases where two word phrases form compounds such as "a walk out", "to walk out", "a put-on", "to put on". In these cases, there is a stress only on the first element of the compound for the nouns but on both elements for the verbs. If a sufficiently complex set of rules are formulated, it is possible to predict the location of 3tre3s in the majority of words for instance in English.

Amplitude modulation is manifested in language by what is most commonly termed as stress. It has, however been observed that what is interpreted by the speaker or hearer as stress has no simple correlation with loudness. Stress is marked by alternations of pitch, loudness, tempo and perceived segment duration.

Trager and Smith (1951) consider **"stress as loudness".** For them loudness is the major factor in the perception of stress. According to Fant (1957) lengthening of syllables is the most obvious physical correlate of stress. He proposed to measure the area under syllable **peak** combining intensity and duration in a single measure. Bolinger (1958) considers **"stress as accent".** Thus, for Bolinger the primary cue of what is usually termed stress in the utterance is pitch prominence. Lieberman (1960) considerd **"stress as rhythm".** According to him it is the rhythm of the sentence that is seen as underlying the perception of stress. Savithri (1987) studied intensity and duration are the important cues.

Fry (1955) has investigated some of the physical correlates of word stress. He measured the duration and intensity of the vowels in a number of words, such as 'permit' and 'object' which may be used either as a verb or as a noun. He found that the syllable which had the longest duration and the greatest intensity was the syllable which listeners judged to be stressed. So in language like English length has been found to play a major role, and loudness a subsidiary part, in German, loudness seems to carry more weight than the length. It seems in French, loudness is more important.

Pitch is one of the most important of several auditory cues for he perception of stress in standard Cophennagen Danish (Thorsen, 1978). There are in addition some language in which stress differences appear to have to linguistic function. Jones (1962) mentions as being in this class, Japanese, Hindustani and Marati.

Studies on stress in India languages has been conducted Firth (1950) in Hindi; Balasubramanain (1981) and Jaya (1992) in Tamil, Rathna et al (1981), Savithri (1987) and Raju Pratap (1991) in Kannada,

Investigations of Rathna, Nataraja and Subramanyaiah, (1981) showed that a relative increase in intensity, steepness of the intensity rise, a pause before the word and a large duration of the word are the features observed contributing to stress in Kannada language.

According to Savithri (1987) intensity and duration are the important cues.

Raju Pratap (1991) and Jaya (1992) Studied stress development in normals and found that 90% stress development achieved by 4 years and 5 to 6 years age respectively.

It appears therefore that the important cues for stress may differ from language to language. Though difference of opinions exist, all of them agree that increments in F_o, duration, intensity and alternations in the vowel quality are the primary acoustic cues of stress.

Many methods have been proposed in the past to locate stress. Lieberman (1960) gave a flow chart to represent his method of locating stressed syllables in pairs of syllables, from acoustic cues alone. (Fig. 2). The F_o criterion at the top of the flow chart corresponds to the traditional notion of "pitch-prominence". Lieberman's flow chart represents a program for mechanically recognizing the stressed syllables in stress pairs.

The first step of this program is to note the syllable that has the higher fundamental frequency. This is indicated on the diagram by the positive arrow. If the amplitude of this syllable is also higher, then it is the stressed syllable. If however, the peak amplitude is lower as indicated by the negative arrow, the integral of the amplitude with respect to time over the pitch difference and amplitude ratio between the stressed and unstressed syllables fall into the permissible area, then the syllable is stressed. Many other paths can be followed that all arrive at either a stressed or unstressed judgement. In Lieberman's study the judgements made on the basis of this scheme on his data were in agreement with the perceptual stress judgements 99.2% of the time.

Development in children has been studied extensively. Two hypotheses have emerged from the literature regarding children's initial state in stress. The first, which one can term as the neural start hypothesis according to the holds that children begin the learning process with no stress preferences. The child begins presumably with level stress or within difference to the distribution of stress both in babblings and at the outset of speaking. Then the stress habits of community assert themselves quickly and decisively (Leopold, 1947). In contrast, Allen and Hawkins (1977, 1979, 1980) have hypothesised that children have a natural bias towards producing words with Trochaic rhythm (an accented syllable followed by an unaccented syllable.

Children's ability to understand and use stress develop as they grow. Also, it is generally agreed that infants perception of stress precedes production. Even very young infants show some sensitivity to prosodic aspects of speech of adults (Morse, 1972; Mehler and Bertoncini, 1979). It has rather been argued that infants respond first to suprasegmental patterns in the speech around them (Lewis, 1951; Crystal, 1970). Spring and Dale (1977) discovered that 1-4 months old infants correctly discriminated disyllables with differing only in the placement of stress as signalled by F_o, duration and intensity differences. Infact, infants were able to discriminate syllables differing only in duration.

Spring and Dale's (1977) study was directed towards two goals. First, was to explore the ability of young infants to discriminate syllabic stress i.e., the contrast which differentiates the meaning of two word3 eg. Black bird vs. Black bird. Second, was to evaluate the ability of young infants to discriminate stimulus differences on the basis of duration cues alone. It was found that young infants were able to discriminate the acoustic correlates of stress location (F_o, intensity and duration) and also could discriminate durational difference along, without concomitant variations in the naturally correlated parameters of F_o and intensity. Spring and Dale (1977) concluded that, infants have atleast some stress related information available which may serve as the foundation for lexical and syntactical learning.

Hornby (1971) found that first and third graders performed essentially chance in interpreting stress cues to topic-comment structure. Mackhinney, Pleh and Bates (1985) in a study of sentence understanding in Hungarian found that 6 year olds could use stress as a cue to thematic role assignment almost as efficiently as adults could; 3 and 4 years, however failed to make use of the stress cue. Solan (1980) studied 33 children with the age range of 5-7 years. The intent of the study was to trace the children's development of rules interpreting contrastive stress. Children were presented with sentences such as "John hit Bill and then he hit Sam". An act out procedure with toys was used as a response. It was found that when pronoun was stressed, the children performed better (80%) than when it was unstressed (60%). This gap was closed at higher age group.

Studies concerned with contrastive stress generally showed that children both use and understand contrastive stress as a make of focus at a young age. Hornby (1973) compared children's understanding of sentences, whose focus was marked by a syntactic device (clefting), with their understanding of simple sentences whose focus was marked by means of contrastive stress. Results showed that the stressed sentences were significantly easier for the children's identification of focus than were the clefted sentences indicating that for children talking loudly is easier than learning syntax.

Myers and Myers (1983) examined normal children (k-6) in their ability to judge the appropriateness of the stress patterns of sentence pairs. They discovered a steady progression in this capacity but with marked variation, even among their older children. The study indicated that skill in judging the correctness of stress cues which distinguish emphasis in meaning seem to be one that matured even into adolescence.

Cross linguistic studies have been conducted on the development of stress. Gleitman and Wanner (1982) have argued persuasively that cross linguistic asymmetries in the acquisition of certain morphosyntactic features can be explained as the universal application of a strategy "pay attention to stressed syllables". Thus, language specific interrelations of stress patterns and morphology underlie language specific acquisition patterns. The prosodic perception of young children is in some cases better than might be predicted. Allen (1983) showed that 4 year old French children correctly perceived stress contrast not found in their language (but typical of English and other stress languages), whereas the same children at the age 5 more fully in command of the prosodic structures of their own language, no longer reliably distinguished the non native contrasts.

b) Production of stress: Children's use of stress also begins in young age. Brown (1973) noted that one of his subjects used the contrastive stress technique to introduce new information prior to the age of 2 years. His subject eve, aged 10 months contrasted sentences "that papa nose" and "that eva nose" by application of contrastive stress. Evidence of early use of contrastive stress was also provided by Weir (1962) who noted extra heavy stress for the emotive function of language, in her 2 1/2 years old son's speech. Slobin and Welsh (1967) found contrastive stress generally imitated by the 2 year old child they studied.

Klein's (1984) study of a 2 year old's lexical stress patterns found that although this child had considerable difficulty imitating lexical stress patterns, his spontaneous productions of words familiar to him used consistent and correct stress placement. At the utterance stress level, Machwinney and Bates (1978) showed that children used stress to distinguish newly given information by age 3. In a similar context, Weiman (1976) also showed, that children whose mean length of utterance measured 1.3 - 2.3 morphemes already showed an established stress pattern and that stress assignment highly correlated with semantic content, in particular with the introduction of new information. Raju Pratap (1991) studied the development of word stress in the range of 3-4 years old normal children who were native Kannada speakers. Results indicated that the production of word stress increased from 3-4 years in both males and females for clauses and sentences. However, even at 4 years children did not achieve 100% score except for female children in the age range of 3.10 - 4 years. Allen and Hawkins (1980) analysed the acoustic properties of 3 types of syllables, namely nuclear accented (stressed), non-nuclear accented and heavy unaccented syllables in the speech of 3 children age and 36 ± 4 months. In most respects, the acoustic patterning associated with stress accent and position of a syllable in the phrase in 3 year olds speech closely resembled the pattern found in adult speech and indicated that children have internalised the basic rules of stress or accent in English i.e. they have mastered the production of stress at the age of 3 years. Hochberg (1987 b) studied the acquisition of stress in Spanish language and he opines that by 3 years of age children learn the rules of stress. Progressing to somewhat older population, Hornby and Hass (1970) found that the normal 4 year old children were able to mark comment in an utterance by use of contrastive stress.

Chomsky (1971) examined the effect of contrastive stress on person references. She found that contrastive stress was successfully established by the age of 6 years for the subjects she studied.

Atkinson-King (1973) showed that by the age of 12, her subjects were perceiving and producing stress in a fully adult manner. The results of these studies indicate that stress develops from infant 3tage and continues upto 12-13 years and is language dependent.

PRODUCTION OF STRESS IN HEARING IMPAIRED CHILDREN:

Several investigators (Stark et al 1974, Gold 1975, McGarr 1976) have shown that the hard-of-hearing children have difficulty in producing such features as 3tress, pausal juncture and intonation. The studies on stress, indicate that the hearing impaired children are very poor in the production of stress. It has been found that the hearing-impaired children do not sufficiently vary the differences in durations of unstressed and stressed syllables (Angelocci 1962, Nickerson 1974). Boone (1966) opines that it looks as if the hard-of-hearing produce only stressed syllables. Levitt et al (1974) comment that the hard-or-hearing speakers produce the temporal feature of pause better than stress.

The most common error type, in the prosodic feature production task, is the production of the sentence with equal stress followed by equal pause for each syllable i.e.

staccato (McGarr et al, 1978). When acoustic analysis of stress contrasts produced by hearing-impaired children was performed, it was found that the syllables that the subjects intended to stress were perceived by the listeners as stressed (Murphy et al, 1990). This is a very rare finding. Also, research indicates that the hearing-impaired speakers are less accurate in lexical and metrical distressing (Graddol, 1991).

The studies on the reception of stress shows that they perform poorly on such tasks as they find much difficulty in perceiving the differences in frequency and intensity. (Smith 1973, Stark et al, 1974). All these studies indicate that though there are variations within the group on the type of error noted, overall as a group, the hard-of-hearing perform poorly on tasks involving production or reception of stress.

Lexical stress, seems to be an important cue to word identification (Gaitenby et al. 1977). Studies of hearing speakers have established the importance of three acoustic cues (vowel duration, amplitude and fundamental frequency) in conveying lexical stress.

Speech produced by persons with severe to profound hearing loss, has been described as "Staccato like' suggesting a failure to differentiate stressed and unstressed syllables. Another common description is "Flat and devoid of melody" suggesting a failure to vary Fo. As duration intensity and fundamental frequency are the major cues for stress, when these are not varied appropriately, the production of stress is also affected. It has been found that, the hearing impaired children do not make sufficient difference between the stressed and unstressed syllable. They prolong the durations of both stressed and unstressed syllables, the increase trends to be proportionally greater for the unstressed sounds (Angelocci, 1962). The hearing impaired speakers fail to make the difference between the durations of stressed and unstressed syllable sufficiently large (Nickerson et al, 1974).

It has been found that the ratio between the stressed syllable and a preceding unstressed syllable is typically less, in the hearing-impaired population. Speakers with normal hearing lengthen stressed syllables and syllables in wrod final and sentence final positions (Parmenter & Trevino, 1936; Fry, 1958, Klatt, 1974; Lindblom and Rapp, 1973). A stressed syllable in final position is likely to be 3-5 times, as long as a preceding unstressed syllable, for the hearing impaired speakers, the ratio is typically much smaller than this (John & Howarth, 1965).

It is almost as though the deaf speakers produces only stressed syllables and in fact investigators have suggested that this problem, is, in part a result of training that put3 greater emphasis on the articulation of individual speech sounds in isolation or in isolated consonant vowel syllables (Boone, 1966). The hearing impaired speakers tend to increase the duration of the unstressed syllables. They produce unstressed syllables twice longer than the normals (Boothroyd et al 1974).

The hearing impaired children produced the temporal feature of pause better than stress. The deaf children were asked to produce, six sentences using two forms of stress (early and late), pause (early and late) and question. These sentence types were presented to the children in written form. The children's attempts to produce the sentences were tape-recorded. Atleast two independent listeners then judged whether or not the child had produced the required sentence form correctly. The children were found to be able to produce the temporal feature of pause best. Stress was less easy for them although they were better able to produce this feature at the end of a sentence than at the beginning. The judgement of staccato was made 27 percent of the time (Levitt and Stark, 1974).

Though, there are equivocal studies, regarding clues for stress, it has been found that the stressed syllables produced by hearing impaired speakers were usually accompanied by an Fo change (Nickerson, 1975). When contrasting stress, intonation, and juncture or pause were tested, the hearing impaired tended to perform poorly in the production of stress.

Mcgarr and Osberger (1978) found that the children did less well on production of stress. The children seemed to be slightly better in producing a stressed form that occurred near the end of a sentence than one that occurred near the beginning. The most common error type was production of the sentence with equal stress followed by equal pause for each syllable (i.e. Staccato).

When acoustic analysis of stress contrasts produced by the hearing impaired children was performed, it was found that the syllables, the subjects intended to stress were perceived by the listeners as stressed. In this study, there were two groups, speakers and listeners. The speakers were seven females and six males ranging in age from 9 to 19 years (mean age of 13.9 years) with congenital profound hearing loss. Each subject produced three nominally spondiac words:- cupcake, bath tub and hot dog:- 10 times each, systematically alternating primary lexical stress between the first and the second syllable. Perceptual test and acoustic analysis (vowel duration, peak Fo and peak amplitude) was carried out. It was found that when these subjects correctly) produced stressed syllables, they did so with increased amplitude, duration and fundamental frequency. When they did not, no acoustic feature (on combination on features) accounted for their errors. The data also suggested that there were important between speaker differences in the overall hierarchy of cues adopted to convey lexical stress (Murphy et al, 1990). It has been found that lexical distressing and metrical distressing are less accurate in the hearing impaired children. Graddol (1991) has stated that deaf speakers tend to produce too many stressed syllables is borne out by an analysis of his subject, an eight year old hearing impaired boy.

Sarumathi (1993) studied production of stress in hearing impaired children and found that the production of stress increased from 2 years to 8 years. Males performed better than females almost in all the age group, although the difference was at significant. Even at the of 8 years hearing impaired children did not achieve even 60% score. In general, when the noun was stressed, the hearing impaired children did better in the adjective than on the adverb. She also said that acquisition of stress was delayed in the hearing impaired children. A common error was production of stress in an inappropriate word. Also production of word (phrase/with equal strees followed by equal pause for each syllable (staccato). She said this could be attributed to poor control over the laryngeal and articulatory system with are required for production of stress pattern.

Another error was lack of stress on the key syllable on word. In view of these findings, she had recommended paying attention to prosodic aspects to incorporate it both in evaluation and rehabilitation.

All of these studies indicate that the production of stress among the hearing impaired children is severely affected and it has been indicated that among them the suprasegmental features like intonation, pause, juncture and stress, are not accurately produced.

Temporal aspects include Rhythm, Pause/Juncture and duration. Everyone feels his language to be rhythmic and can give their feelings substance by citing songs or lines of poetry or by simply gesturing 'in time' to his speech, Rythm involves a rule based variation of the fundamental frequency, spectral unformation, amplitude and the relative duration of sound and silence. (speer, Gowder and Thomas (193). These syatametic variations map on to the perception of 3ptress, rythem and intonation in the spoken language. Fairbank (1945) defines rhythm in speech as a pattern of vocal change, which is inherent in speech which draws attention to the need for regular ventilation or breathing pattern which underlies pause, stress, rate pitch and intensity.

Rhythm is the perception of the time program applied to the phonetic events by the speaker. It is frequently used to refer to any kind of repetition or periodicity in the physical world, also for any kind of correspondence in aesthetic experience (Allen, 1973).

In definition of the modern term 'rhythm', both generally and in its specific reference to language, the motor factor has been repeatedly emphasized, eg. (Goodell, Fry, 1958, Abercrombie, 1965. All rhythm, it seems likely, is ultimately rhythm of bodily movement). But patterned movements in many non-linguistic contexts is associated with more or less strict temporal regularity eg. in the rhythms of inanimate and animate nature, in human physiological rhythms such as those of the pulse, respiration, of walking, and in the arts of music and dance. As a result the term rhythm comes to be applied to the pattern of intervals between movements, rather than the qualitative patterns of movements themselves (Allen, 1973).

Prosodic rhythm (Isochrony) may be defined as the perception of a patterned time program underlying sequences of speech. Absolutely no authority would question the universal perception of speech as rhythmic. The ability of untrained speakers to engage in choral reading and inter and intra subject reliability in tapping speech rhythm of any given speech sequence is part of the language competence. In fact, the perception of speech rhythms may be 'innate' in human infants. Condon and Sanders (1974) played tapes of adults speech to new born infants while filming their body movements. Frame-by-frame analysis of the films revealed that as early as the first day of life the neonates movements were in synchrony with the rhythm of speech they were hearing.

Balasubramanian (1980) conducted a series of experiments to study rhythem in Tamil language. His results showed that tamil language can be called neither stress timed nor syllable timed.

Pause/Juncture:

During continuous speech, it is physiologically necessary for all speakers to insert a certain number of pauses. The occurrence of these pauses depend on the amount of residual air in the lungs (Vaissiere, 1983) Because of physiological constraint, basic similarities in pausing was found between different languages. Studies have also indicated that the ratio of articulated sequences to total speaking time didn't differ significantly from one language to another (Grosjean & Collias, 1979). The basic function of pause was that of providing time for intake of air. Speakers pause depending on the constituent structure of the utterance, specifically at the end of large conceptual units such as sentences and clauses (Fodor, Bever, and Gamett, 1974; Vaissiere, 1983) pauses between sentences were reported to be lower than pauses within sentences (Goldman - Eisler, 1972; Duez 1982). Pauses were also used to demarcate the intonation groups. (Cruttenden, 1986).

Two varieties of pause have been described by various investigators i.e., unfilled or silent pause and filled pause (Guttenden, 1986); Pauses at grammatical junctures and hesitations pause (Vassiere 1983); tentative pause and final pause (Pike, 1945).

Describing the characteristic of pause in American English, Pike (1945) has stated that tentative pauses were shorter than final pauses, and the syllable preceeding the tentative pauses were shorter than the final pauses and the syllable preceeding the tentative pause was often longer than usual, sustained on a level pitch. The tentative pause helped in sustaining the height of the pitch contour of the sentence. It tends to occur in all places where the attitude of the speaker included uncertainty or non finality. Thus, it could be found in hesitations, and after almost all questions, except for questions asked not wanting an answer or when the answer was known (Pike, 1945). Pike (1945) printed out also stated that the final pause was usually longer than the tentative pause and it modified the preceding consonant or consonants by lowering the height the pitch of the end of the consonant. The final pause occurred where the speakers attitude was one of finality, and for this reason occurred most often at the end of statements.

Wells (1986), while describing the attributes of 'focus' in English sentences using a perceptual task, categorized pauses as the attributes of temporal features of the sentences as follows:

a. Preceding pause - pause immediately before the focus constituent.
b. Following pause - pause after the focus constituent.

Cruttenden (1986) hypothesized that pauses generally occurred at three places in speech.

a. At major constituent boundaries - or sentence boundaries (i.e., between clauses and between subject and predicate). Longer pauses were observed in major boundaries, and constituent boundaries involving a new topic. These pauses of the indicated the intonation group boundaries.

b. Before words of high lexical content: This pause generally occurred before a minor constituent verb phrase or adverbial phrase.

c. After the first word in an intonation group. Which was often the position seen with errors of performance such as false starts and repetitions.

Types (b) and (c) were hesitation pauses, and were often seen in all types of unscripted speech than in reading or prepared speech (Crutenden, 1986).

Howell and Kadi-Hanifi (1991), reported major differences in terms of marking the boundaries between tone units, position of stress markings and number and location of pauses in reading and spontaneous speech.

Attributes of pause:

The use of pauses as major boundary markers between and within sentences were similar accross some languages (Vaissiere, 1983). Black, Tosi, Singh and Takefuta (1966) found no significant differences in the use of location of pauses by speakers of English, Hindi, Japanese and Spanish.

However, the length of pauses and their distribution per number of syllables differed slightly from one language to another. Grosjean and Collins (1979) found that native speakers of French tended to pause less often but for a longer time than native speakers of English.

The duration and frequency of pauses also depended on factors which were independent of language. At fast rate of speech, pauses within sentences tended to be suppressed, and pauses were more frequent in descriptions than in interviews (Grosjean and Collins, 1979). Pause distribution tended to be in agreement with grammatical structure in political speech than in interviews (Duez, 1982). In the sixth repetition of a spontaneous description, subjects made only half as many pauses were used when reading unusual stories as compared to ordinary ones (O'Connell and Kowal, 1972).

Commenting on the segmental durations in Japanese, Takeda, Sagisaka and Kuwabara (1989), found that the pre-pausal lengthening was greater than simple word final lengthening and sentence final position had shorter durations. Crutteden (1986), commented that the criterion of pause as a maker of intonation group boundaries could not be used on its own. Despite its explicit or implicit use as such in many studies and text book on intonation, pauses did not always mark intonation boundaries, nor were intonation boundaries always marked by pauses. Pauses could only be used as a criterion for intonation boundaries if considered together with other external and internal criteria.

Strangert and Zhi (1989) looked at the occurrence of perceived pauses with respect to syntactic and textual structure. The syntactic boundaries in the text were identified between paragraph, sentence, clause and phrase boundary Five potential correlates of pauses at these boundaries were measured. They were: (a) Presence of inhalation (b) Silent interval (c) prepausal lengthening (d) Fo before and after a pause and (e) voice quality irregularities. Results indicated that: (a) inhalation occurred at almost every pause except for pauses at phrase boundaries (b) the longest intervals occurred at paragraph boundaries, the inter mediate intervals at sentence boundaries, and the shortest intervals at clause and phrase boundaries and at non-boundary positions. (c) The pre-pausal lengthening was greatest before phrase boundaries and moderate at paragraph boundaries (d) The Fo before a pause tended to be inversely proportionate to the order of the boundary at that pause. Fo after a pause, on the other hand, varied little between different boundaries. Thus, the extent of resetting was greater as the order of the boundary increased, (e) The majority of pauses with irregular voice quality occurred at paragraph and sentence boundaries. Thus, it was concluded that the different boundary categories had different manifestations. In general, the higher the rank of the boundary, the stronger and more varied were the correlates of a pause.

From an experiment, Shriberg and Lickley (1993), observed that there was a drop in the Fo of clause - internal filled pauses which did not seem to be absolute or random relative to prior prosodic context in American and British English speakers. The drop in Fo value of the clause -internal filled pauses was predicted to be an invariant proportionate to the distance from the preceding peak Fo value to the observed baseline. It was also observed that the intonation of filled pauses could be independent of temporal variables.

From the review, it is evident that duration of segments and also the pauses are significant, related to stress and intonation phenomenon.

Temporal Abberrants in the Hearing Impaired:

With few exceptions, the speech of the severely and profoundly hearing impaired is perceived as being too slow and sounding very labored. Physical measures of speaking rate have shown that profoundly hearing-impaired speakers, on the average, take 1.5 to 2.0 times longer to produce the same utterance as do normal hearing speakers (Boone, 1966; Heidinger, 1972; Hood, 1966). The reduced speaking rate is due to the excessive prolongation of speech segments and the insertion of pauses. According to Gold (1978) reduced rate of speech the deaf speaker is due to (a) Increased duration of phonemes (b) Improper and often prolonged pause within utterances.

Prolongation of speech segments may be present in the production of phonemes, syllables, and words. Calvert (1961) was among the first to obtain objective measurements of phonemic duration in the speech of the hearing impaired by spectrographic analysis of bisyllabic words. The results of this study showed that hearing-impaired speakers extended the duration of vowels, fricatives, and the closure period of plosives up to five times the average duration for normal speakers. In a later study, Osberger and Levitt (1979) observed that syllable prolongation in the speech of the hearing impaired was due primarily to prolongation of vowels.

Figure 3 shows data obtained by Osberger (1978) on mean syllable duration in a sentence produced by six normally hearing and six profoundly hearing-impaired children. The data show a distinctive pattern of syllable durations for the two groups of speakers. The line connecting the data points of the hearing impaired speakers lies above and is approximately parallel to that of the hearing children. The exception to this is the sixth syllable where the mean syllable duration is shorter for the hearing-impaired than the normal speakers. This was due to the omission of some of the phonemes in the syllable by the hearing-impaired speakers, making the duration of the syllable shorter than would be expected if all of the intended segments had been

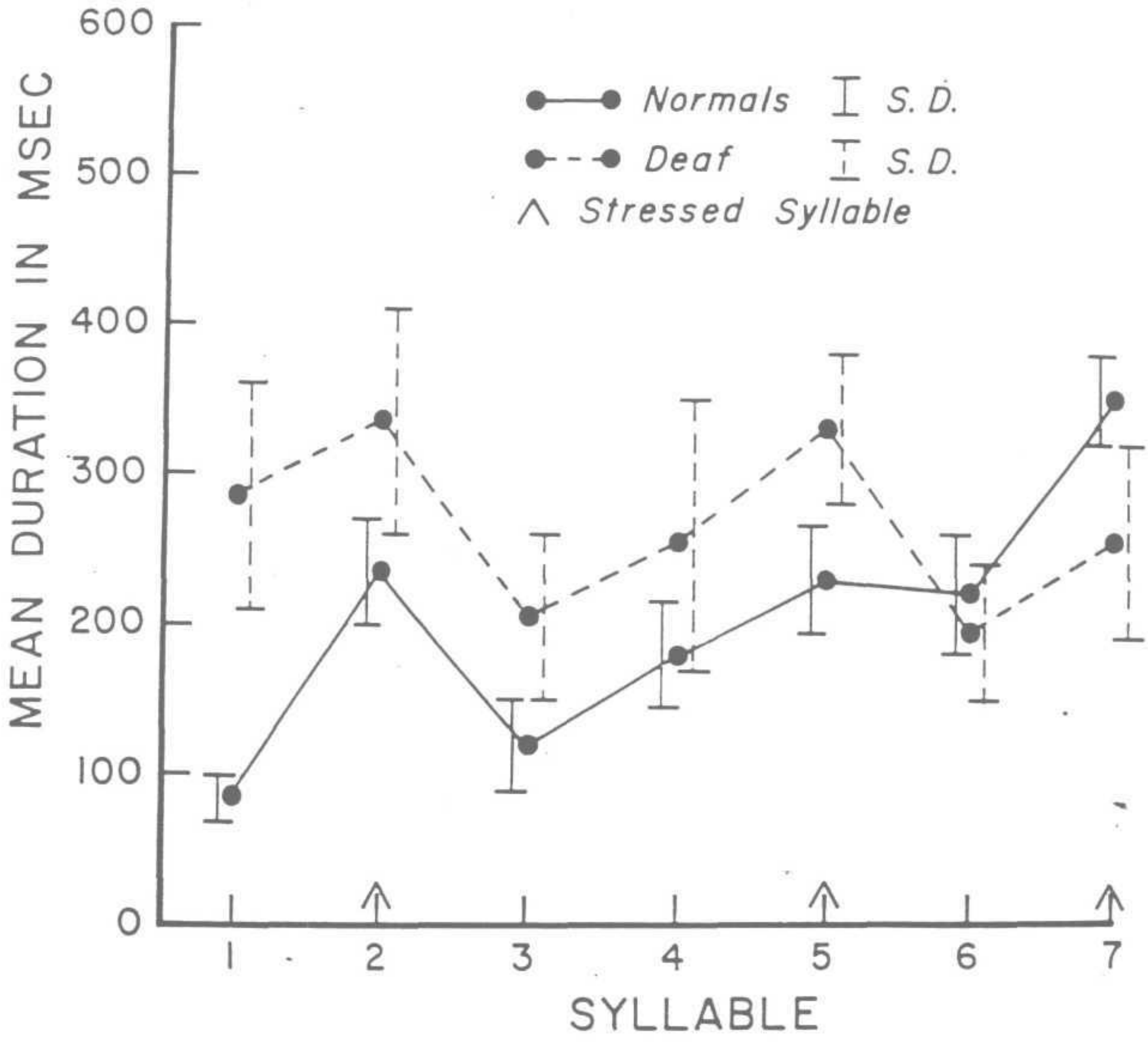


Figure 3. Mean duration (msec) for syllables in the sentence "I wish I could read that book" produced by six normal-hearing children and six hearing-impaired children. The standard deviation is represented by the vertical bars (after Osberger, 1978).

produced. The size of the standard deviations, shown by the vertical bars, indicates that there is greater variability in syllable by the hearing-impaired speakers, making the duration of the syllable shorter than would be expected if all of the intended segments had been produced. The size of the standard deviations, shown by the vertical bars, indicated that there is greater variability in syllable duration among the hearing-impaired than among the normal speakers.

Profoundly hearing-impaired speakers typically insert more pauses, and pauses of longer duration, than do speakers with normal hearing (Boone, 1966; Boothroyd, Nickerson, & Stevens, 1974; Stevens, Nickerson, & Rollins, 1978). Pauses may be inserted at syntactically inappropriate boundaries such as between two syllables in a bisyllabic word or within phrases. The greatest difference between normal and hearing-impaired speakers has been observed in the durations of inter and intraphra3e pauses (Stevens et al., 1978). The results of Hudgins (1934, 1937, 1946) suggested that the frequent pauses observed in the speech of the hearing impaired may be the result of poor respiratory control. Specifically, Hudgins (1946) found that deaf children used short, irregular breath groups often with only one or two words, and breath pauses that interrupted the flow of speech at inappropriate places. In addition, there was excessive expenditure of breath on single syllables, false groupings of syllables, and misplacements of accents.

Segmental Timing Effects:

Acoustic analysis of normal speech have shown that the duration of vowels is systematically influenced by effects operating at the level of phonetic segments. Since vowels form the nuclei of larger segments of speech, these differences in vowel duration exert substantial effects on both the production and perception of the temporal and segmental aspects of speech. Vowels have been described as having an intrinsic duration (Peterson & Lehiste, 1960) and, in comparable contexts, some vowels are consistently shorter than other vowels (House, 1961). Hering-impaired speakers with severe and profound losses have been found to distort this relationship between the vowels. For example, Monsen (1974) observed that /i/ was relatively longer than /I/ in monosyllabic words in the speech of normal hearing subjects, but in the speech of profoundly hearing-impaired children, there was a tendency for these vowels to occupy mutualy exclusive duration ranges. McGarr and Harris (1980), on the other hand, found that the profoundly hearing impaired speaker in their study did not show consistent differences in intrinsic vowel duration.

There is substantial literature showing that the average duration of vowels also varied markedly as a function of phonetic context in normal speech. When different phonetic contexts are considered, the voicing characteristic of the following consonant has been shown to have a consistent effect on preceding vowel duration. For normal speakers, the duration of a vowel preceding a voiceless consonant is less than the vowel duration preceding a voiced consonant in stressed syllables (Denes, 1955; House, 1961; House & Fairbanks, 1953; Peterson & Lehiste, 1960). This systematic change in vowel duration has been found to be a significant perceptual cue to the voicing characteristic of the following consonant or consonant cluster (Raphael, 1972). Results obtained by Calvert (1961) and Monsen (1974) have shown that the hearing impaired fail to produce the appropriate modifications in vowel duration as a function of the voicing characteristics of the following consonant. Thus, the frequent voiced-voiceless confusions observed in the speech of the deaf may actually be due to vowel duration errors (Calvert, 1961).

Suprasegmental Timing Effects:

The duration of segments is also influenced by effects operating at the level of syllables, words, and phrases. In English, changes in contrastive stress have been found to produce systematic changes in vowel duration. When vowels are stressed, they are longer in duration than when the same vowels are unstressed (Parmenter & Trevino, 1936). This durational variation has also been found to be an important cue for the perception of stress (Fry, 1955, 1958).

Deaf speakers produce fewer words per minute than normals both because they prolong words and syllables and because they pause for abnormal periods between words.

Several investigations have shown that while hearing-impaired speakers make the duration of unstressed syllables shorter than that of the stressed syllables, the proportional shortening is smaller on the average, in the speech of the hearing impaired than in the speech of normal subjects equalising the duration of stressed and unstressed syllable in sentence production. (Osberger & Levitt, 1979; Stevens et al., 1978). In contrast to thi3, Reilly (1979) found larger than normal duration differences between vowels in primary and weak-stress syllable produced by a group of profoundly hearing impaired children.

Exactly a hearing-impaired speaker uses temporal manipulations to convey differences in syllabic stress pattern is not clear. In a recent study, McGarr and Harris (1980) found that even though intended stressed vowels were always longer than unstressed vowels in the speech of one profoundly hearing-impaired speaker, the intended stress pattern was not always perceived correctly by a listener. Thus, the hearing-impaired speaker was using some other suprasegmental feature to convey contrastive stress. Variation in fundamental frequency would be a likely alternative, but McGarr and Harris (1980) also found that while the hearing-impaired speaker produced the systematic changes in fundamental frequency associated with syllable stress, perceptual confusions involving stress pattern were still observed.

Another suprasegmental temporal effect occurring in normal speech is prepausal lengthening. When a syllable occurs before a pause that marks a major syntactic boundary, it is longer in duration than when it occurs in other positions in a phrase (Klatt, 1975). It has been observed that hearing-impaired speakers do not always lengthen the duration of phrase-final syllables relative to the duration of the other syllables in the phrase. Stevens et al. (1978) observed that when there was evidence of prepausal lengthening in the speech of profoundly hearing-impaired talkers, the increase in the duration of the final syllable was much smaller, on the average, for the hearing impaired than for the normal-hearing speakers. In contrast to this, Reilly (1979) found that the profoundly hearing-impaired speakers in her study used duration to differentiate prepausal and non-prepausal syllables. As was the case for primary and weak-stress syllables, Reilly (1979) observed a larger than normal difference between the duration of syllables in the prepausal and non-prepausal position in the samples produced by the hearing-impaired children.

The information presented above clearly shows that profoundly hearing-impaired speakers distort many temporal aspects of speech. These distortions, such as excessively prolonged speech segments, and the insertion of both frequent and lengthy pauses, are perceptually prominent and disrupt the rhythmic aspects of speech. In spite of these deviancies, there is evidence suggesting that hearing-impaired talkers manipulate some aspects of duration, such as those involving relative duration, in a manner similar to that of speakers with normal hearing. In fact Levitt et al (1980) reported that deaf use durational ones in place of intonation. Levitt et al (1980) reported that the deaf use durational cues in place of intonation. Thirumalai and Gayathri (1988) in a monograph on Deaf Speech published by C.I.I.L., Mysore, suggest that in many Indian languages including Kannada, durational cues get merged with the intonation cues.

The effect of with lengthening on intelligibility will depend in part on whether length is phonemically distinctive in the language being used.

The above review of literature, provides with a comprehensive view on prosodic aspects of speech, and their effect in the speech of the deaf individual. This, it is hoped, will serve as a basis for both comparison and a better understanding of suprasegmentals in the speech of malayalam speaking hearing impaired children, with whom the present study is concerned.

CHAPTER - III

METHODOLOGY

The study aimed at investigating the prosodic or suprasegmental aspects of the speech of Malayalam speaking hearing impaired children, by comparison with the prosody exhibited by an age matched normal hearing control group.

SUBJECTS:

Experimental group:

10 hearing impaired subjects (5 male and 5 female), in the age range of 3 1/2 - 5 1/2 yrs, whose pure tone hearing threshold levels (HTL's) exceeded 70dB as per ANSI 1969 standards.

All the subjects were undergoing speech and language therapy at the All India Institute of Speech and hearing, Mysore. Only those children having good expressive language of at least sentence level and could narrate a story when pictures were presented were selected for the study.

Control group:

10 normal hearing subjects (5 males and 5 females) in the age range of 3 1/2 to 5 1/2 yrs, with no known history of speech or hearing problems as evaluated by qualified speech pathologists were considered under this group.

All the subjects had normal intelligence, and were all native speakers of Malayalam. The experimental group and control group were matched for age and sex.

TEST MATERIAL:

Sequential picture card depicting the story of the hare and the tortoise with a simple sentence in written form describing the picture, corresponding to each picture card, served as the test material. The sentences were simple enough so that the hearing impaired could also read them.

SPEECH SAMPLES FOR ANALYSIS:

Each subject was required to narrate the story of the hare and the tortoise. The story was first explained to them, with actions so that each child understood it and the emotions involved - joy when winning, sorrow when losing, etc. The story was then presented to them in a structured manner i.e. the words to be used in describing the story was given to them in the form of 8 simple sentences. This was done, for the purpose of maintaining uniformity between the hearing impaired and normal hearing group, in the words used, and to eliminate morphological variability, which would facilitate comparison of prosody between the 2 groups.

The subjects were seated comfortably. The mic was placed at a distance of 6 inches from the subjects mouth. All the hearing impaired subjects wore their hearing aids. They were then asked to narrate the story. The speech sample thus elicited, was recorded using the Sony deck TC-FX170 tape recorder.

Each subject narrated the story 3 times, and the best of 3 samples was used in the study for analysis.

INSTRUMENTATION:

1. H-Legend D-80 microphone
2. Tape recorder - Sony deck - TC FX170
3. Philips pre amplifier
4. Sharp AH 307 stereo head phone.
5. Pentium HCL computer with 200 MHz processor.
6. Printer Epson Fx 105.
7. A-D/D-A converter (12 bit.)

The instruments were arranged as shown in the block diagram.

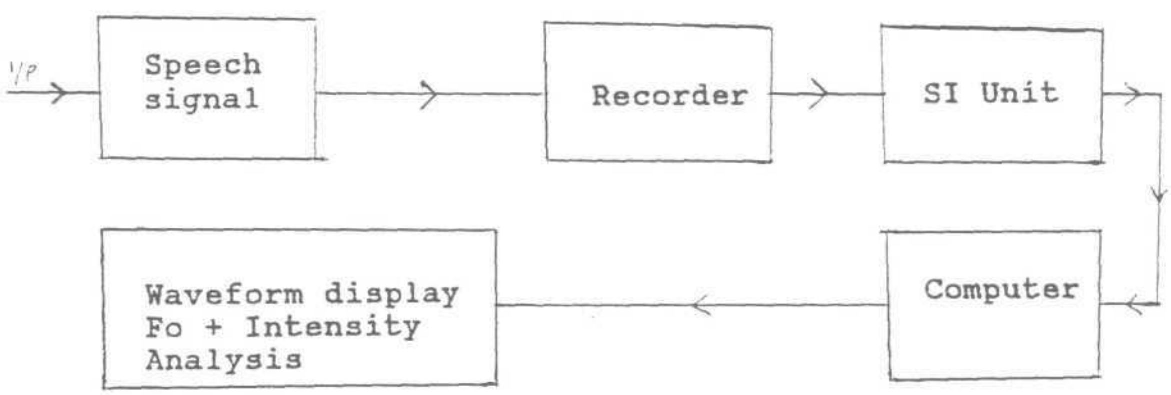
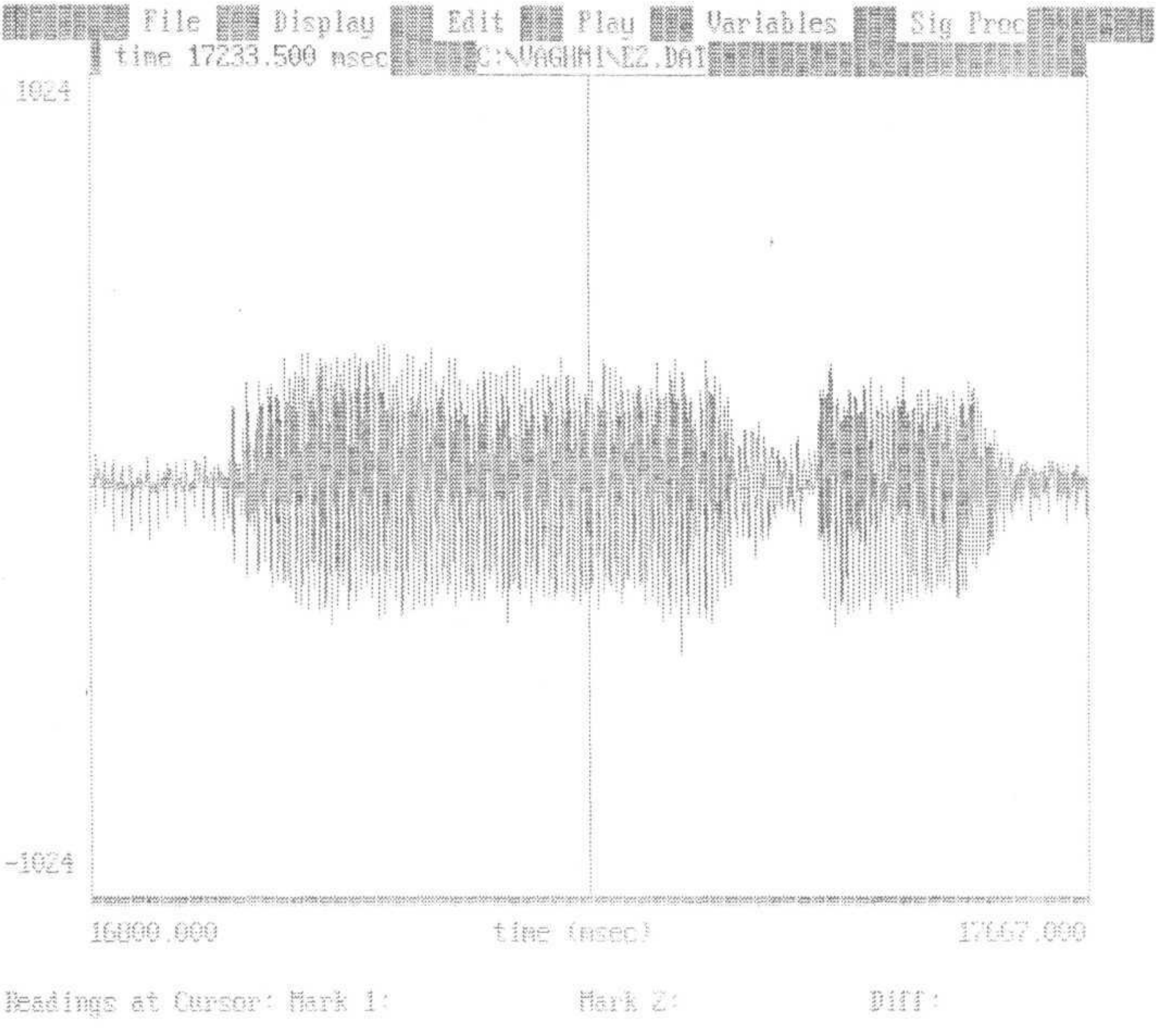


Fig: Block diagram showing the arrangement of instruments for the purpose of recording and analysis of speech.

Analysis Procedure

The recorded sample that is, each sentence at a time was fed through speech interface unit, (12 bit A/D Converter) and digitised at a sampling rate of 16000 Hz and stored in the harddisc of the computer. Before digitising, each sample was passed through the anti-aliasing filter at 3.5 KHz with a role off of 48dB per octave. The level indicators of the Speech Interface unit was used to monitor the intensity level to avoid any distortion while digitising the signal.

Each sentence was analyzed using the software packages SSL and Vagmhi, developed by Voice and Speech Systems, Bangalore and the fundamental frequency and intensity readings of the samples were extracted. The digitised signal was displayed on the computer screen using the programme, Display, On execution of this programme, a specified portion of the speech signal will be displayed on the monitor of the computer. A vertical cursor, which can be moved horizontally, was used to mark a specific portion on the waveform, highlight, and listen to the signal present in that marked part of the waveform, and to note the time at any given point or points on the waveform. Using this, one can segment, edit or measure the duration of any desired portion of the waveform. All the sentences spoken by the subjects of both the groups were analysed and temporal parameters obtained. The speech waveform was visually inspected for 3ilent intervals and the duration of silence was then calculated by


File
Display
Edit
Play
Variables
Sig Proc
time 17233.500 msec
C:\VAGHMI\EZ.DAT
1024
-1024
16800.000
time (msec)
17667.000
Readings at Cursor: Mark 1:
Mark 2:
Diff:

placing the cursors at the points of pause onset and termination. Pause onset was defined as the point where the waveform stopped crossing the zero axis on the display screen, and the pause termination was defined as the point where the waveform next crossed the zero axis. The portion was highlighted every time and listened to through headphones, for better validity. When pauses were identified, their location and duration was noted (both interword and intraword pauses). Locations were confirmed by an acoustic play back of the portion of the signal surrounding the pause. The duration of the syllables were also noted by the same procedure. The syllable duration, word duration, and also the intra word and inter word pauses were computed using this programme.

The speaking rate, was calculated by dividing by the total number of syllables in the story by the time taken to narrate the story. The story consisted of 8 sentences. However, as the fifth and sixth sentences had some words which were difficult for the hearing impaired subjects, they were not said properly by 80% of the hearing impaired subjects. Hence only the remaining six sentences were analysed to obtain the results.

Programme Inton, of VSS software was then used to extract the Fundamental frequency and intensity curves for each sentence uttered by the subjects. This programme enabled simultaneous visualization of the fundamental frequency pattern for a given portion of speech signal, the intonation contours and also the waveform. A vertical cursor, which could be moved horizontally, enabled marking of a particular point on the wave form. The fundamental frequency and Intensity measures corresponding to this point could be noted at the point where the cursor was placed on the waveform. Averaged fundamental frequency and intensity variations for each syllable were extracted, and the following fundamental frequency (Fo) and intensity statistics were also obtained.

1) Mean fundamental frequency (in Hz)
2) Range of fundamental frequency (in Hz)
3) Mean intensity (in dB)
4) Range of intensity (in dB)

A table consisting of Fo and Intensity values at every 10 ms duration were obtained for each sentence of every speaker. (P.T.O)

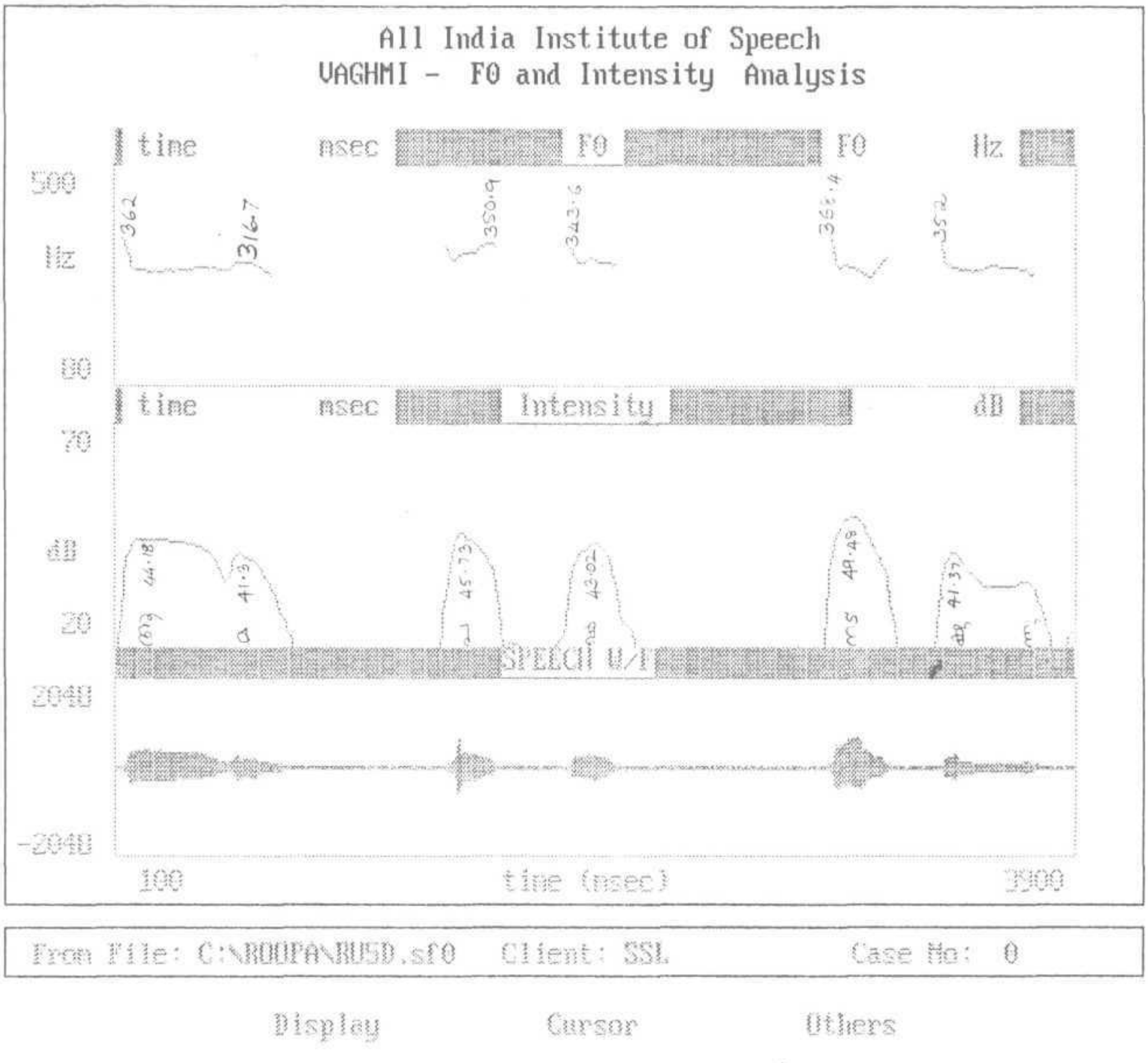
Analysis was carried out considering syllable as the basic unit (House et al. 1989). The locus of stress as evidenced by higher fundamental frequency intensity and longer duration were determined using the data given in the table with Fo Intensity and duration for each 10 ms of each sentence. Syllable boundaries were identified from the speech wave form display and also fundamental frequency waveform. The subjective analysis was also done by the experimenter and one more judge who had experience in the analysis of the intonation contours of the normal and hearing impaired subjects.

VAGHMI - INTON

Case Name : KP
Case No : 1
Date : 12-09-1997
Time : 15:15:43

Duration	FO	Intensity	VUS
250	130.0813	34.18079	X
260	128	34.06842	X
270	137.931	34.28432	X
280	181.8182	33.68968	X
290	100	32.06229	X
300	0	30.78095	S
310	0	31.56817	S
320	347.8261	32.57186	X
330	94.11765	32.64074	X
340	94.67455	34.73016	X
350	144.1441	34.84388	X
360	380.9524	34.68477	X
370	326.5306	34.36615	X
380	306.8327	35.71373	V
390	81.21828	34.77524	X
400	347.8261	35.0507	X

A printout of the fo and intensity curves and waveforms were obtained using the printer (Epson Fx105) and the Fo and Intensity values corresponding to the stressed syllables, was noted on it. They were then compared to see whether both the groups had stressed on the same syllables or not, and also to determine whether there was a set pattern of deviance in the hearing impaired speech. The intonation contours were compared, to find the pattern of intonation in the hearing impaired and normals.


All India Institute of Speech
VAGHMI - F0 and Intensity Analysis
time
msec
F0
F0
Hz
500
Hz
80
Intensity
dB
70
dB
20
SPEECH U/V
2048
-2048
100
time (msec)
3900
From File: C:\ROOPA\RUSD.sf0
Client: SSL
Case No: 0
Display
Cursor
Others

STATISTICAL ANALYSIS:

Following acoustical analysis the data was subjected to descriptive statistical analysis and the mean, standard deviation, and range were obtained for all the parameters studied.

The values obtained were further subjected to the Mann Whitney U test (SPSS Programme) to find out whether there is any significant difference between the normal and hearing impaired groups and also between the male and female groups.

CHAPTER - IV

RESULTS & DISCUSSION

This study aimed at finding out whether there were any significant differences in the prosody of normal hearing and hearing impaired subjects (5 male and 5 female, aged 3 1/2 - 5 1/2 years) with malayalam as mother tongue, in a story narration task.

Each sentence was analyzed to find out the intonation pattern of the sentence, the loci of stress in the sentence and the duration of pauses, both intra word & inter word pauses. The values obtained were then compiled to obtain the measures for the entire story and also he rate of speech during narration. The values were compared between normal & hearing impaired, and also between males and females for gender differences. The results thus obtained, were as follows.

1. Fundamental Frequency or Pitch Pattern

The mean fundamental frequency (Fo) and range of fundamental frequency (Fo range) in the speech of the normal hearing and hearing impaired subjects, ware measured as follows.

Key to Abbreviations in tables

I_aWP = Intra Word Pause	S = Significant
I_rWP = Inter Word Pause	NS = Not significant
T.P = Total Pauses	Fo = Fundamental Frequency
%P = Percentage of Pauses	FR = Frequency Range
HM = Hearing impaired male	I = Intensity
HF = Hearing impaired female	IR = Intensity Range
NM = Normal male	SD = Standard Deviation
NF = Normal female	

a) Normal males Vs Normal females.

	Fo		FR	
	NM	NF	NM	NF
MEAN	286.53	287.64	116.51	179.61
RANGE	14.75	21.12	90.65	134.78
S.D	6.22	7.57	31.16	49.08
	NS		S	

Table 1: Showing Mean, Range & Standard Deviation of Fo and Frequency Range in the speech of normal and hearing impaired males and females.

As shown in Table 1, the mean Fundamental frequency of the normal females was slightly higher than that of the normal hearing males, a mean of 286.53Hz and 287.64 Hz respectively, but the difference between them was not statistically significant. This is probably because the subjects were children, aged between 3 1/2 - 5 1/2 years, and hence gender difference in Fo was not that pronounced. Kushal raj (1983) and Hasek et al (1981) also reported no significant difference in Fo between males and females till the age of 11 years. However, the range of Fo exhibited by the normal females was significantly higher than that of the normal hearing males. Hence, the hypothesis that there was no significant difference between the Fo of normal males and females (in the age group 3 1/2 to 5 1/2 years) was accepted.

b. Hearing Impaired Males vs. Hearing Impaired Females.

	Fo		FR	
	HM	HF	HM	HF
MEAN	283.9	302.6	137	197.8
RANGE	22.59	24.15	40.1	246.6
S.D	10.1	9.7	14.8	86.28
	NS		NS	

Table 2: Showing the Fo of hearing impaired males & hearing impaired females in terms of mean, standard deviation & range.

The mean Fo for hearing impaired females was 302.6 Hz which is higher than that of the hearing impaired males, who had a mean Fo of 283.9 Hz. However the difference between them was not statistically significant. The range of frequencies exhibited was also higher for the females than for the males, but again the difference was not significant. Hence, the hypothesis stating that there is no significant difference between mean Fo of hearing impaired males and females was not accepted.

C. Normal females Vs Hearing Impaired females.

	Fo		F	
	NF	HF	NF	HF
MEAN	286.53	302.62	179.6	197.77
RANGE	21.12	24.15	134.78	246.62
S.D	7.56	9.7	49.07	86.3
	S		NS	

Table 3: Shows the mean, range and standard deviation of fundamental frequency and fundamental frequency range (F_o range) of normal hearing females and hearing impaired females.

The mean speaking fundamental frequency of the hearing impaired females who had a mean Fo of 302.62 Hz. was significantly higher than that of normal hearing females whose mean Fo was 286.53Hz. This finding is in line with the results of studies by Angelcocci et al (1964); Boone (1966) and Martony (1968), which also showed a higher F_o in the speech of the hearing impaired, than in the normal hearing.

The range of F_o of hearing impaired females was also higher than that of the normal hearing females, but the difference between them was not statistically significant. Hence, the hypothesis stating that there is no significant difference in mean F_o & frequency range of normal females & hearing impaired females, was not accepted.

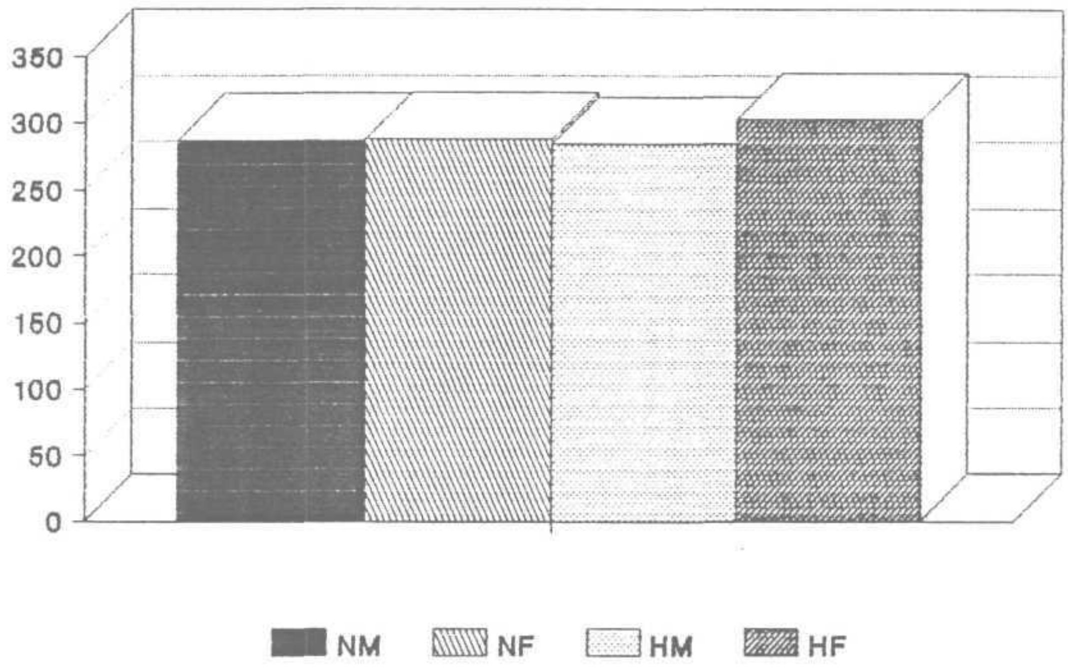
d) Normal male Vs Hearing Impaired male.

	Fo		FR	
	NM	HM	NM	HM
MEAN	287.64	283.6	116.5	137
RANGE	14.75	22.9	90.65	40.1
S.D	6.22	10.11	3.1	14.8
	NS		NS	

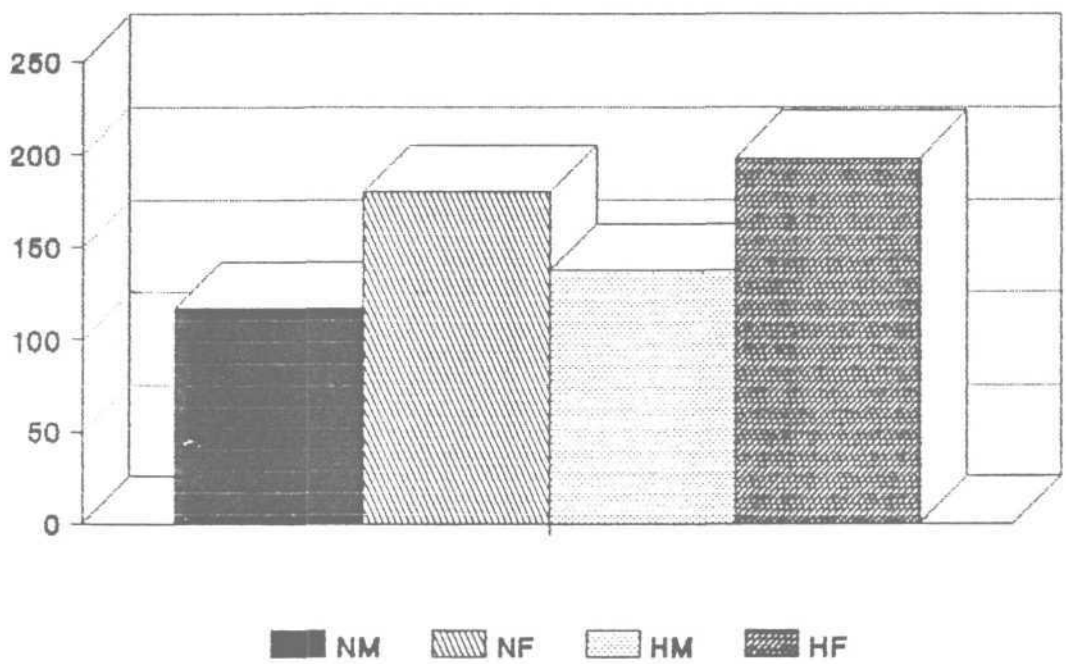
Table 4: Showing values of Fo in hearing impaired males and normal hearing males in terms of mean, range and standard deviation.

Study of Table 4 shows that the F_o of normal males was 287.64 Hz and that of hearing impaired males was 283.6Hz. Unlike earlier studies which had reported of a significant difference between the Fo values of normal hearing males and hearing impaired males and also unlike the results of the comparison of normal hearing and hearing impaired females in the present study, no significant difference was found between either the mean F_o or the range of Fo of the normal hearing males and hearing impaired males. Hence, the hypothesis that there is no significant difference between the Fo & frequency range of hearing impaired males & normal hearing males was accepted. This finding is similar to that of Green (1956) who found similar Fo values in normal & hearing impaired males. However, Meckfessel (1964) and Thonston (1964) reported higher F_o values in hearing impaired males than in normal hearing males.

Fundamental Frequency In Speech of Normal & Hearing Impaired



Frequency Range In Speech of Normal & Hearing Impaired



2. Intenstity values

Normal Males Vs Normals Females

	Fo		FR	
	NM	NF	NM	NF
MEAN	43.33	41.14	23.27	26.68
RANGE	6.79	4.08	11.07	19.57
S.D	2.38	1.51	3.87	7.88
	NS		NS	

Table 5: Showing values of Fo for normal hearing males and normal hearing females on intensity & intensity range in terms of mean, standard deviation, and range.

The mean intensity of speech of normal hearing males was 43.33 dB, slightly higher than that of normal hearing females who had a mean intensity of 41.14dB. There was no statistically significant difference between the mean intensity and intensity range in the speech of normal hearing males and females. Hence, the hypothesis that there no significant difference in the mean and range of intensity of normal males and normal females, was accepted.

b) Hearing impaired males vs hearing impaired females.

	Fo		FR	
	HM	HF	HM	HF
MEAN	33.93	29.27	43.3	45.2
RANGE	5.71	4.71	7.8	8.22
S.D	2.46	1.95	2.56	3.4
	S		NS	

Table 6: Showing values of mean standard deviation of intensity and intensity range of hearing impaired males and hearing impaired females.

The mean intensity exhibited by hearing impaired males was 33.93 dB. This was found to be significantly higher than that of the speech of hearing impaired females who had a mean intensity of 29.27 dB. However, the intensity values were lower than the mean intensity range values in the speech of both normal hearing males and females of the present study (shown in table 5). The range of intensity was marginally, but not significantly higher in the females than in males. Hence, the hypothesis that the intensity was not significantly different between the hearing impaired males & females, was accepted.

c) Normal females and hearing impaired females.

	Fo		FR	
	HF	NF	HF	NF
MEAN	29.27	41.14	45.22	26.68
RANGE	4.71	4.08	8.22	19.57
S.D	1.95	1.51	3.44	7.88
	S		NS	

Table 7: Showing mean intensity, standard deviation and intensity range of normal hearing females and hearing impaired females.

Comparison of mean intensity and range of intensity values of normal hearing and hearing impaired females revealed a statistically significant difference in both of these parameters between the two groups. The normal females had a mean intensity of 45.22dB while the hearing impaired female had a mean intensity of 29.27dB. The mean intensity in speech was significantly higher in the normal female group, and they maintained it without excess intensity fluctuations. However the hearing impaired females had significantly greater range of intensity variations than normal hearing females (26.68 dB mean range). Thus, the hypothesis that there is no significant difference in mean intensity & intensity range between normal females and hearing impaired females was not accepted.

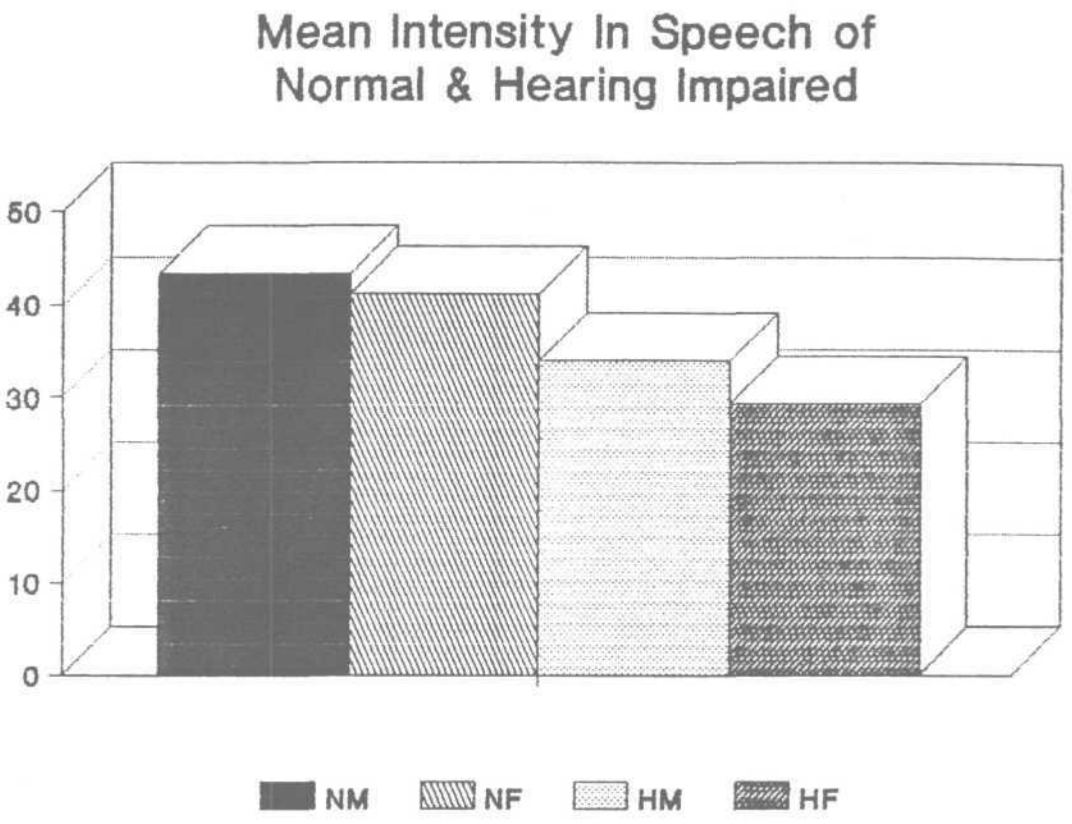
d) Normal males Vs hearing impaired males.

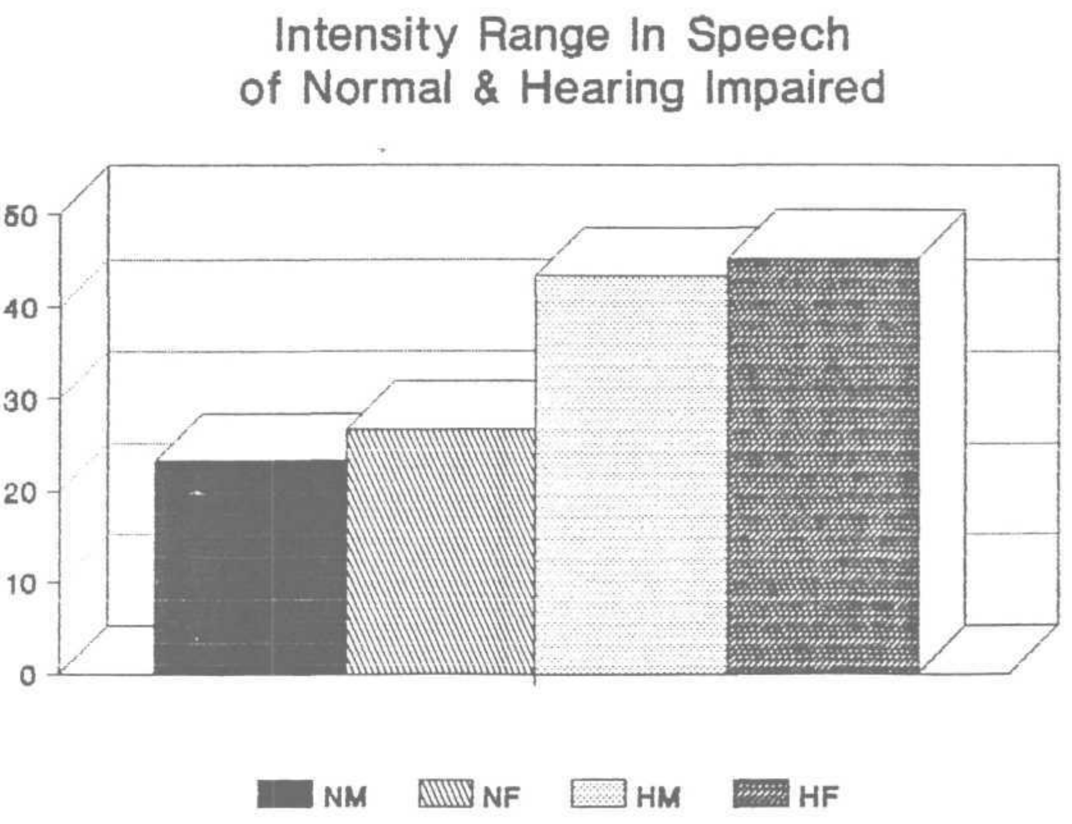
	Fo		FR	
	NM	HM	NM	HM
MEAN	33.93	43.33	43.33	23.28
RANGE	5.71	6.79	7.8	11.07
S.D	2.46	2.38	2.56	3.87
	S		S	

Table 8: Showing mean, Range and standard deviation of mean intensity & intensity range in the speech of normal hearing males and hearing impaired males.

The normal hearing males had a mean intensity of 33.93 dB and a range of 43.3 dB while that of the hearing impaired males was 43.33 dB with a range of 23.28. Comparison of mean intensity and intensity range of normal males and hearing impaired males revealed a significant difference in terms of both these parameters between the two groups. Thus the hypothesis stating that there is no significant difference between the speech of normal and hearing impaired males interms of the mean intensity and intensity range was not accepted.

Taken together, the results of the comparisons of fundamental frequency and intensity, show significant differences between the hearing impaired group and the normal hearing group, with no significant difference between the males and females of these two groups.


Mean Intensity In Speech of
Normal & Hearing Impaired
0
10
20
30
40
50
NM
NF
HM
HF


Intensity Range In Speech
of Normal & Hearing Impaired
0
10
20
30
40
50
NM
NF
HM
HF

3. Stress

The syllable has been considered as the fundamental unit for analysis stress as in most of the studies on prosodic features. Hence, in the present study also the syllable was considered as the basic unit. Stressed syllables were identified on the basis of higher fundamental frequency, and/or longer duration and /or higher intensity. (Fry 1955, Lieberman 1960, Thorsen, 1980). Among the hearing impaired the locus of stress was on any syllable of the word. i.e. there no set pattern was observed. However, in the normal hearing subjects, stress was laid mostly on the final syllable in 90% of the words. Only when the word had greater semantic value, did the initial syllable had greater stress in the normals. eg:- on /Ou/ in the word /Oudanunnu/ meaning 'starting[1], where the intention of the speaker was to convey the fact that the hare and the tortoise were 'starting' ' the race, and not 'ending it. Such semantic pattering of stress was not seen in the hearing impaired.

None of the polysyllabic words uttered by the normals had stress in medially located syllables. However, in the hearing impaired subjects, the placement of stress was often found to be on the middle syllable of the word.

The hearing impaired uttered most syllables with greater force than required, especially if the consonant contained in the syllable was more difficult for the hearing impaired child to utter. The syllable was then produced with greater effort, resulting in greater force, and hence greater frequency, intensity & duration, making the syllable stressed, inappropriately. Hence, the locus of stress was often found to be inappropriate in the hearing impaired.

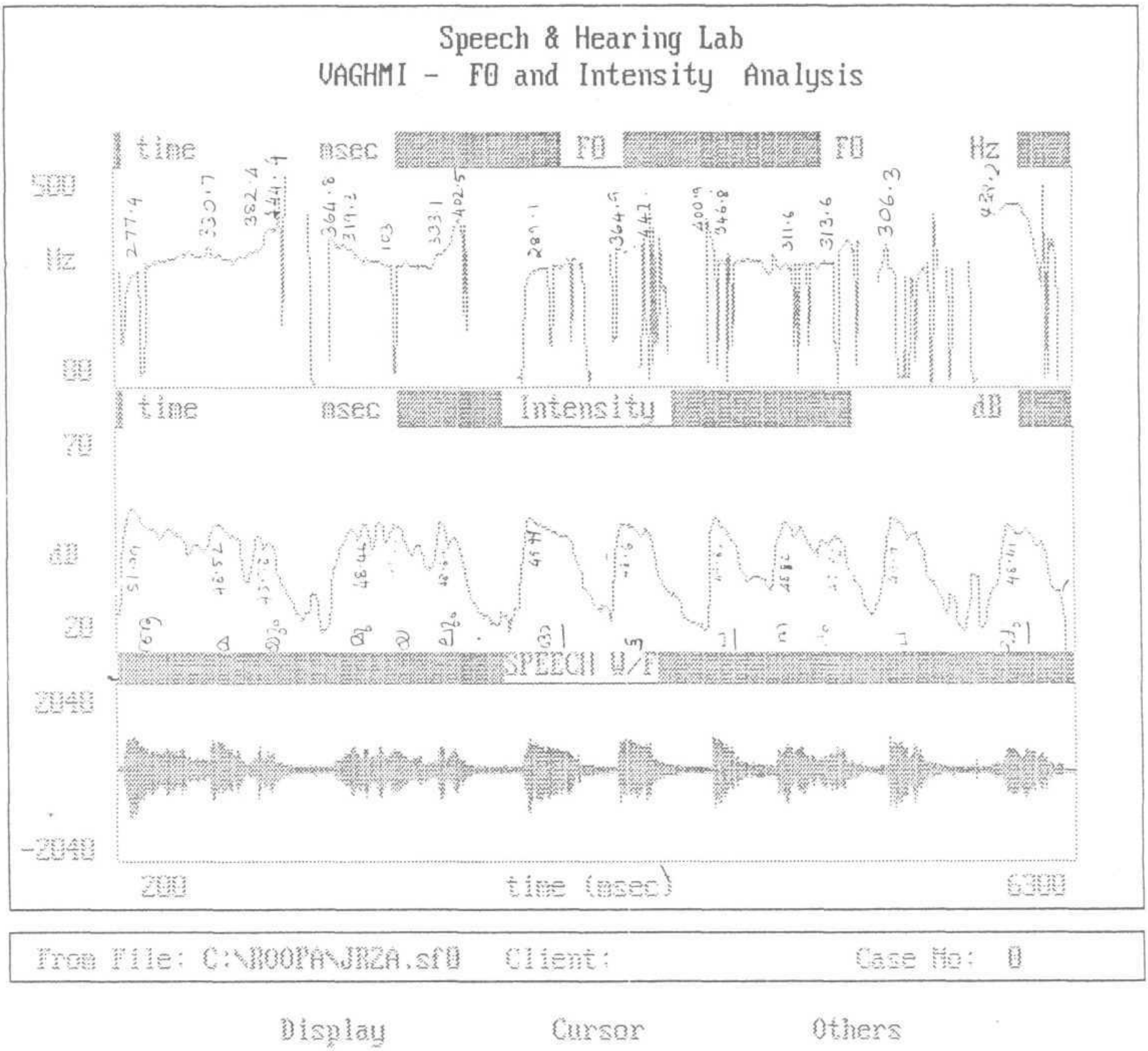
It was also noted that in the normal hearing subjects, the syllable after a pause or phrase was mostly stressed. Similar findings were reported by Manjula (1997) in Kannada language. Due to this the syllable in post pause position and post phrase boundary position had longer duration (because it was stressed), rather than increased duration of pre pausal and pre boundary sounds as reported by Delattre (1966) and Campbell and Isard (1991) in English language.

In the hearing impaired, there was a pause after almost every syllable, and hence this effect was less pronounced.

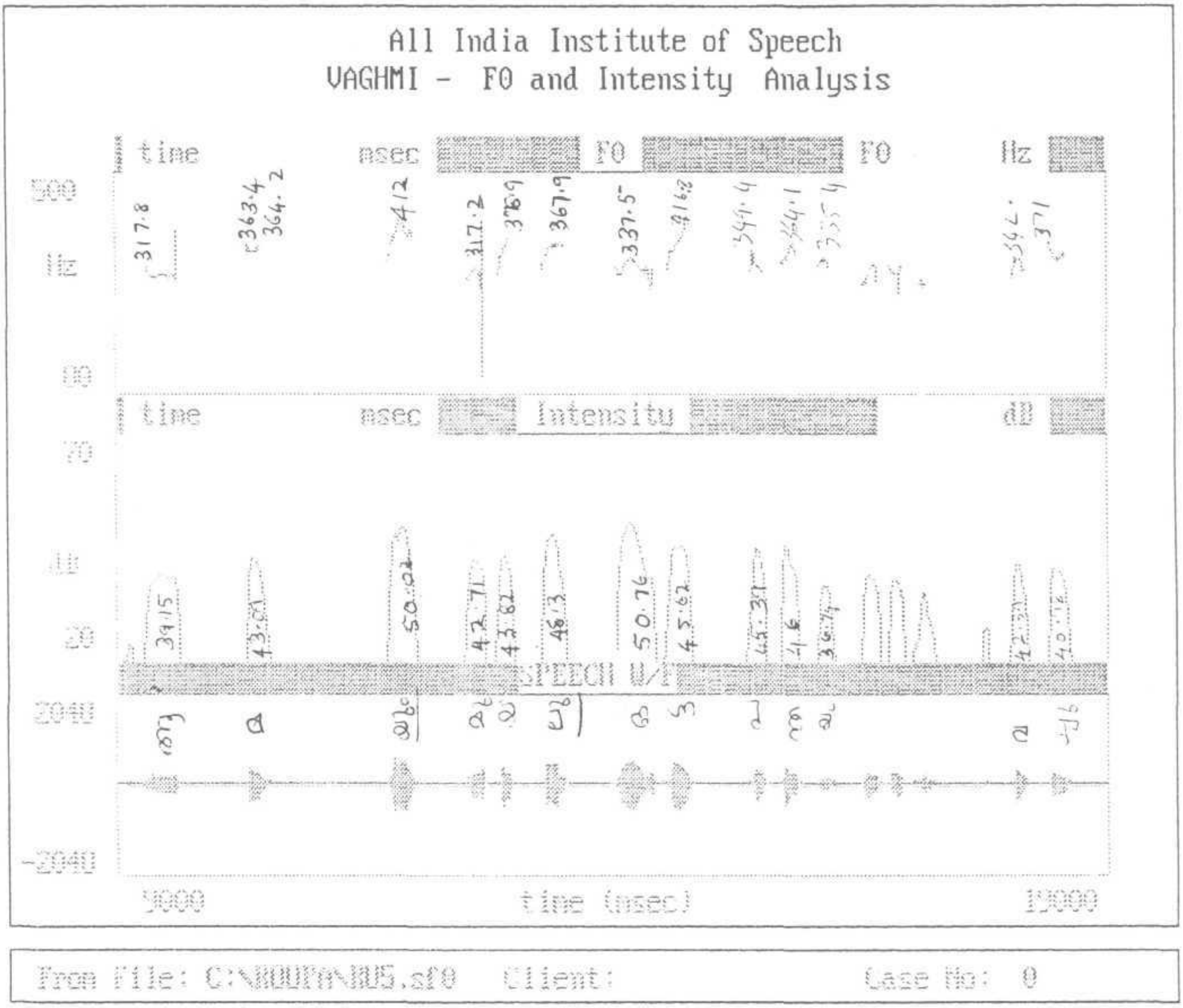
4. **Intonation**:

Comparison of the F_o and intensity graphs of the normal and hearing impaired speakers, showed that the contours of normal speakers were continuous and smoothly varying, whereas the intonation contours of the hearing impaired speaker was discontinuous, with numerous breaks in between due to the high incidence of pauses in their utterances.

* A difference of 20 Hz or more between two levels was considered adequate for the production of 'rise or fall', and any change of less than 20 Hz was considered as 'flat'.



Normal Hearing Declarative Sentence (Sent. 1)



Hearing Impaired Declarative Sentence (Sent 1)

* Of the 6 sentences analyzed, the first four were uttered mostly like a declarative utterance by all the subjects. The patterns most commonly seen in the normals was rise-fall-rise-fall-flat-fall; rise-fall-rise-fall, and flat-rise-flat-fall.

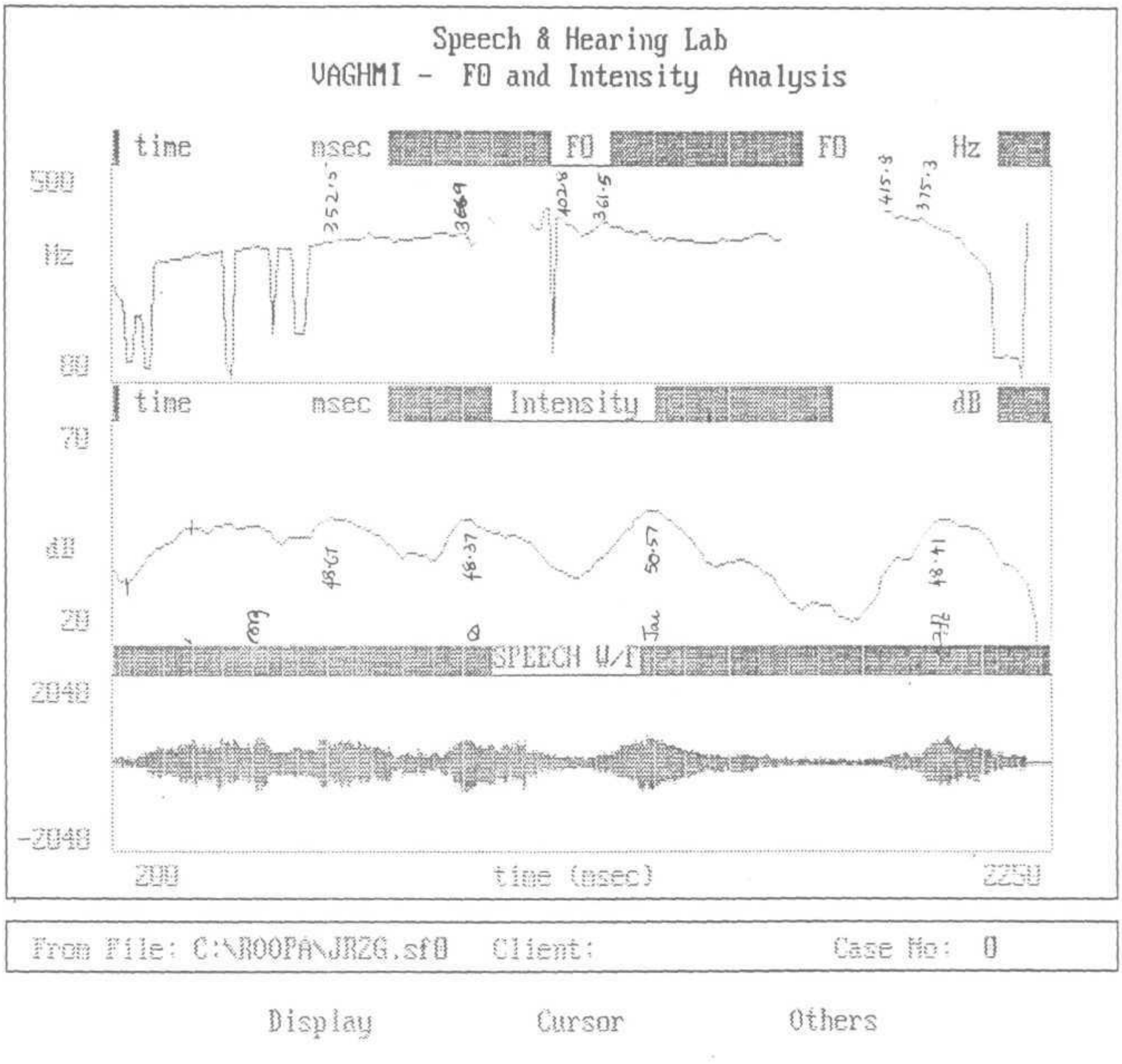
In the hearing impaired, although the curves were discontinuous, when the peaks were joined together, and the frequency & intensity values of the syllables were compared, the pattern most commonly seen was rise-fall-rise-fall.

The F_o showed a gradual lowering throughout the utterance (declination tendency). Such constant rate of declination of Fo was observed in majority of speakers in uttering sentences. (Cruttenden (1986); Vaissiere, (1983), claimed that F_o of all spoken utterances had a downdrift contour and even if the contour of a sentence does not look declining, it is still governed by the underlying declination rule.

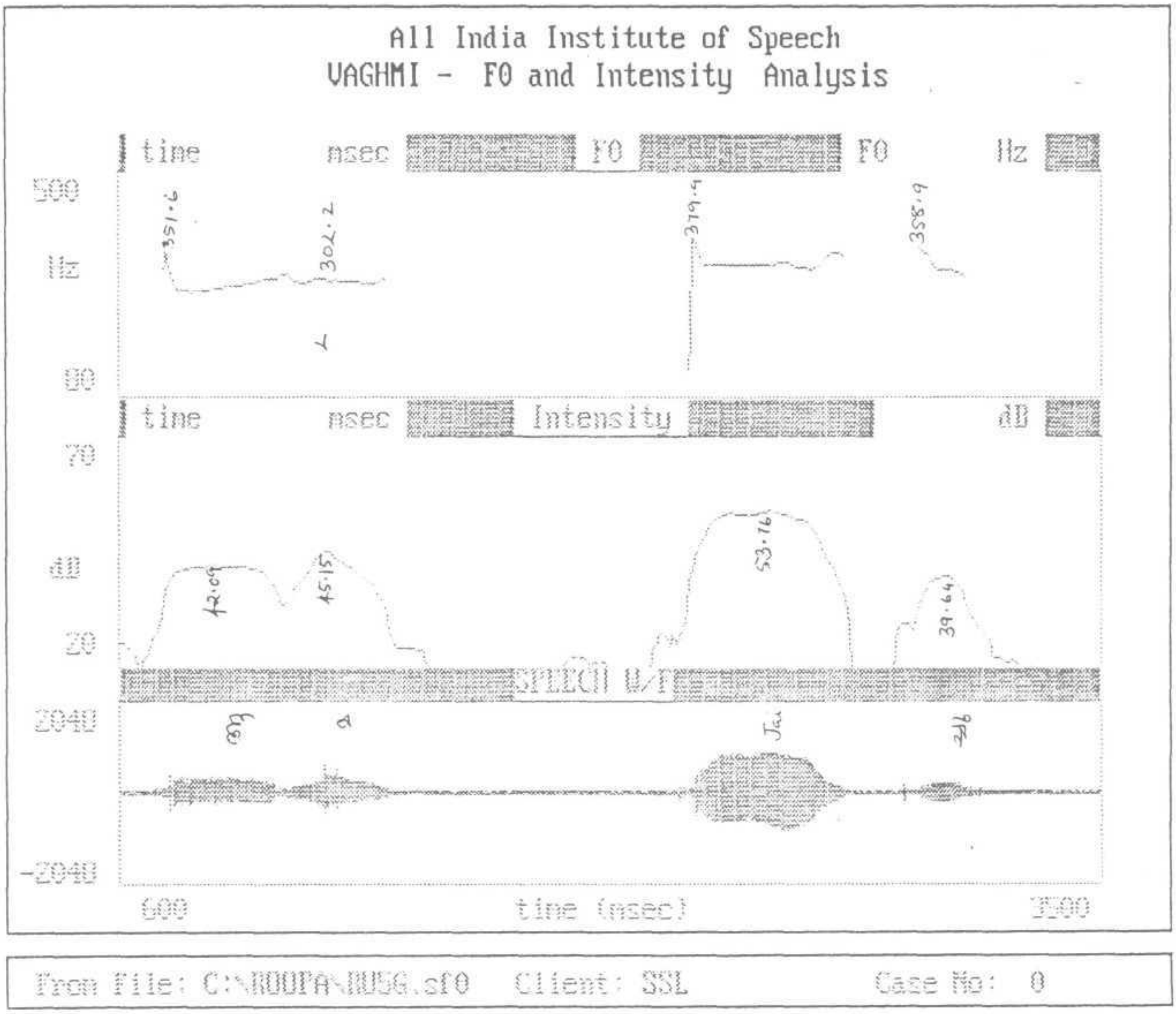
Intensity patterns of malayalam speakers producing a statement, was described by Mini (1997) as

(1) Flat-gradually falling pattern.
(2) Rise-fall-rise-flat-fall-rise-fall pattern.

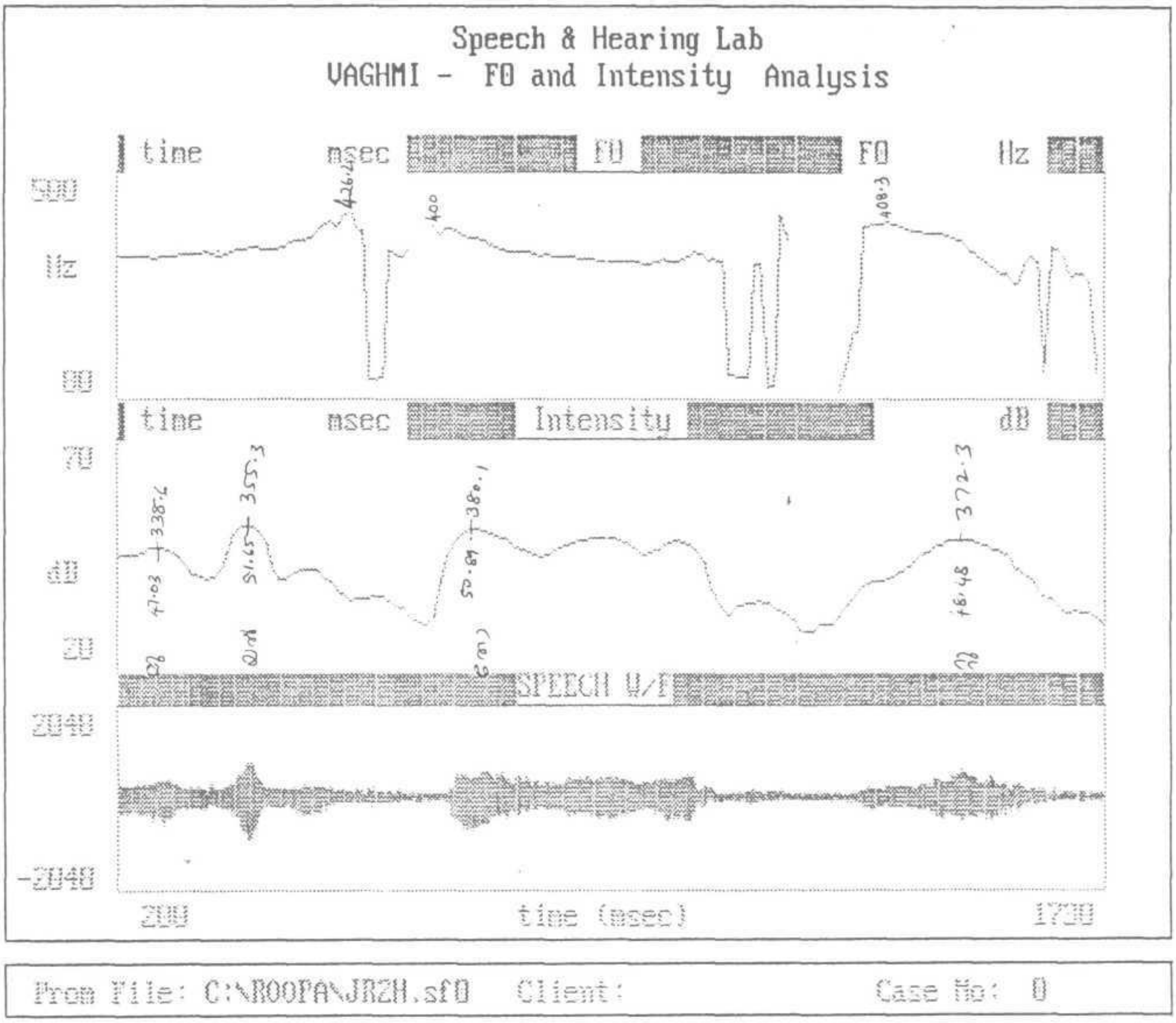
The typical F_o and Intensity contour for the fifth sentence spoken by the normal and hearing impaired speakers is given in fig. The sentence was /a:ma dzaitsu/ (the tortoise won).



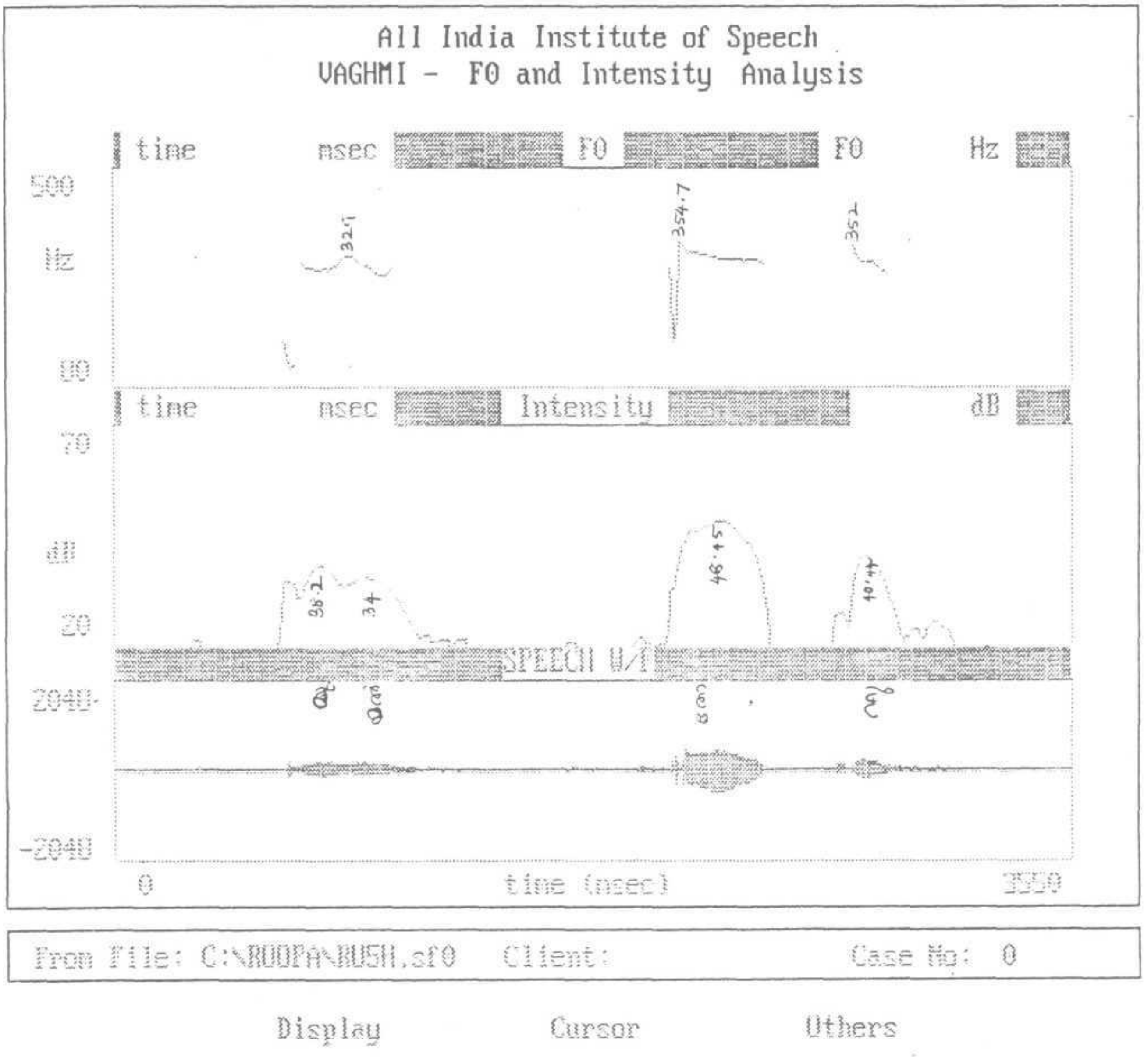
Normal Hearing Subject (Sent 5)



Hearing Impaired Subject (Sent 5)



Normal Hearing Subject (Sent 6)



Hearing Impaired Subject (Sent 6)

more abruptly by the hearing impaired. The pattern most commonly exhibited by the normals was a gradual rise-gradual fall. The hearing impaired showed fall-rise-fall-rise-fall pattern.

In general, a declination pattern was seen. Nataraja (1985) found that malayalam speakers used mid-low-mid frequency patterns to express disappointment. Mini (1997) concluded from her study that majority of malayalam speakers used flat-rise-fall-flat & fall-flat-rise-flat-rise patterns of frequency & a rise-fall pattern of intensity to express disappointment.

5. Temporal Aspects

a) Rate of Speech- The rate of speech was expressed in terms of syllables/second in the present study.

The mean rate of speech of the normal children for story narration was 3.03 syll/sec. whereas the rate of speech of the hearing impaired subjects was 1.1 syll/sec. i.e.:- 3 times slower than the normals. The difference between the rate of speech of the two groups was found to be significantly different as per the results of Mann Whitney U test. studies by Boone (1966); Heidinger (1972), Hood (1966), have also shown that the speech of severely profoundly hearing impaired was perceived as being too slow or very laboured. Physical measures of speaking rats by the investigators, showed, that on the average, hearing impaired speakers take 1.5 to 2 times longer to produce the same utterance as do normal hearing speakers.

The decrease in rate of speech in the hearing impaired may be attributable to the insertion of excessive number of pauses in their speech, and pauses of longer duration than speakers with normal hearing. (Boone 1966; Boothroyd, Nickerson and Stevens, 1974). According to Gold (1980), reduced rate of speech in the deaf speaker was due to increased duration of phoneme and also improper and after prolonged pauses within utterances.

b) Pause Duration

The duration of intraword pause inter word pause and the total duration of pauses were measured for each sentence by moving the cursor on the speech waveform, highlighting the points where the waveform ended crossing the zero axis and then playing the highlighted portion to check whether it was a pause or not. The mean, standard deviation and range of intraword pauses, interword pauses, total pause duration and percentage of pauses for hearing impaired and normals are presented in the following tables.

	IaWP		IrWP		T.P		% P	
	NM	NF	NM	NF	NM	NF	NM	NF
MEAN	60.5	127.0	78.8	141.6	139.3	268.6	8.3	14.0
RANGE	131.2	240.6	146.7	268.5	278.0	508.0	15.24	11.8
S.D	56.3	85.5	56.4	169.4	98.8	202.8	5.4	4.1
	NS		NS		NS		NS	

Table 9: Showing the mean, standard deviation and range of pauses made by normal hearing males and normal hearing females during story narration.

The normal hearing males had an intra word pause of 60.55, and an interword pause of 78.8, making their total pause 193.3 (8.3%). The normal hearing females had an intraword pause of 127 and an interword pause of 141.58, making their total pause 268.6 (14%). The values showed that females have greater amount of pauses -both intra word and inter word pause, compared to males. However, the difference between them was not found to be statistically significant. The hypothesis that there is no significant difference between normal males & females in the duration of pauses, was therefore accepted.

	IaWP		IrWP		T.P		% P	
	HM	HF	HM	HF	HM	HF	HM	HF
MEAN	304.6	561.2	1022.8	1284.6	1327.5	1845.9	37.4	41.66
RANGE	491.6	975.0	1113.8	2533.1	1605.4	3467.4	24.3	18.73
S.D	197.2	363.5	487.7	921.0	609.6	1282.4	8.7	6.5
	NS		NS		NS		NS	

Table 10: Showing the mean, standard deviation & range of pauses made by hearing impaired males and females.

The hearing impaired males had an intraword pause of 304.65, an interword pause of 1022.8 and total pause of 1327.5(37.4%) while the normal hearing males had an intraword pause of 561.25, an interword pause of 1284.66 and total pause of 1845.9 (41.66%). Even among the hearing impaired subjects, the females were found to have more pauses than the males, although the differences between them was not found to be significant statistically. Hence, the hypothesis that there is no significant difference between hearing impaired males & females in terms of duration of pauses was accepted.

	laWP		IrWP		T .P		% P	
	NF	HF	NF	HF	NF	HF	NF	HF
MEAN	127.0	561.2	141.6	1284.7	268.6	1845.9	14.0	41.7
RANGE	240.6	975.0	268.5	2533.1	508.0	3467.4	11.8	18.7
S.D	85.5	363.5	169.4	921.0	202.8	1282.4	4.1	6.5
	S		S		S		S	

Table 11: Showing the mean, standard deviation & range of Pauses shown by hearing impaired females & normal hearing females.

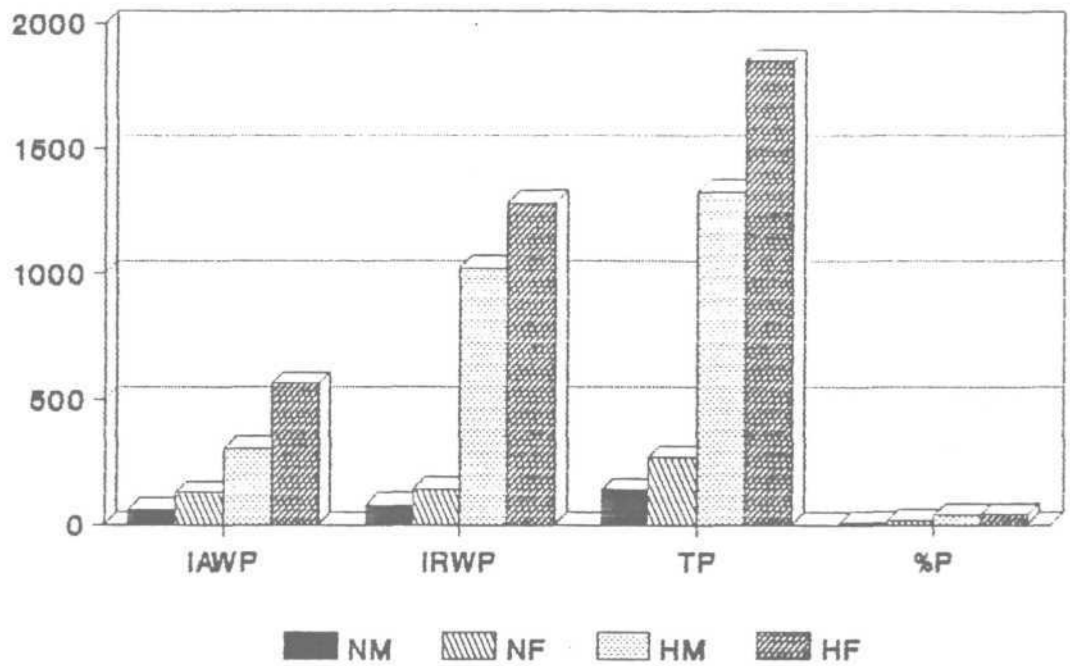
The hearing impaired females had significantly greater amount of pauses with 561.25 intraword pause, 1284.66 interword pause, 1845.9 total pause (41.66%). than normal hearing females with 125. intraword pause, 141.58 interword pause, 268.6 total pause (14%). Thus, the hypothesis that there is no significant difference between normal & impaired females in amount of pauses, was rejected.

	IaWP		IrWP		T.P		% P	
	NM	HM	NM	HM	NM	HM	NM	HM
MEAN	60.5	304.6	78.8	1022.8	139.3	1327.5	8.3	37.4
RANGE	131.2	491.6	146.7	1113.8	278.0	1605.4	15.2	24.3
S.D	56.3	197.2	56.3	487.7	98.8	609.6	5.4	8.7
	S		S		S		S	

Table 12: Showing the mean, range & standard deviation of Pauses shown by hearing impaired males & normal hearing males.

The normal males had an intraword pause of 60.55, an interword pause of 78.8, and total pause of 139.3(8.3%) while the hearing impaired males had a mean intraword pause of 304.65, interword pause of 1022.85 and total pause of 1327.5 (34.27%). The difference in the amount of pauses made by the normal males & hearing impaired males was found to be

Pauses in the Speech of Normal & Hearing Impaired



significant. Hence the hypothesis that there is no significant difference between normal males and hearing impaired males in amount of pauses, was rejected.

The results of significant difference in terms of duration of pauses produced by hearing impaired males and females, as against normal males & females, was supported by studies of stevens, Nickerson & Rollins, (1978); Boone (1966). Hudgins (1946), suggested that the frequent pauses observed in the speech of the hearing impaired, may be the result of poor respiratory control.

c) Timing Effects

It was observed on perceptual analysis by the experimenter, that there was a remarkable consistency in the manner in which the hearing impaired subjects perturbed normal speech timing relationships. They didn't vary the duration of stressed syllables in accordance with the durational recoding observed in normal speech. This is suggestive of a linguistic organization that differs from that of normal hearing speakers. (Metz, 1980).

The hearing impaired speakers linguistic units that serve as domains for the application of specific timing rules appears to be considerably different from the linguistic units reportedly used by normal hearing speakers. (Cooper et al, 1977).

The hearing impaired subjects in the present study, also showed less smooth transition from one syllable to another (poor coarticulation). This finding is consistent with the research findings of Whitehead & Jones (1978) who reported that normal coarticulatory activity is disturbed in the speech of profoundly hearing impaired persons. From the speech perception point of view, the hearing impaired speaker's failure to appropriately vary duration could have serious consequences on the overall intelligibility of his utterances.

Evidence from research on speech physiology suggests that synchronous articulatory movements are the result of a temporal grouping of motor instructions sent to the periphery. (Kent et al 1974). Metz (1980) suggested that the hearing impaired speakers temporal groupings of motor instructions differ considerably from those of normal hearing speakers. He proposed that the loss in speech intelligibility associated with retraining rhythmic elements of speech produced by hearing impaired speakers is the result of imposing timing patterns which interfere with the speaker's unique temporal organization of articulatory features.

The list of findings of the present study are as follows,

1) Significantly higher mean speaking fundamental frequency in the hearing impaired females compared to normal hearing females.

2) Overall Higher speaking fundamental frequency in the hearing impaired than the normals.

3) Significantly lower mean intensity in the hearing impaired male than in the normal male.

4) Significantly lower mean intensity in the hearing impaired female than in the normal female.

5) Significantly lower mean intensity in the hearing impaired female than in the hearing impaired male.

6) Locus of stress was varied in the hearing impaired, while it was mainly on the final syllable in the normals.

7) The hearing impaired stressed when on the medial syllable in polysyllabic words, which was not seen in normals.

8) Post-pausal or post-phrasal syllables were more stressed in the normals. This was not seen in the hearing impaired.

9) The intonation patterns of the hearing impaired had an overall similar pattern, However, it was more discontinuous, with poor coarticulation, and greater number of pauses.

10) The frequency showed a gradual lowering throughout the utterance (declination tendency).

11) The rate of speech of the normals was three times faster than that of the hearing impaired.

12) Females in general had greater amount of pauses, though the difference wasn't significant.

13) The hearing impaired had significantly greater amount of pauses than their normal hearing peers.

14) Speech timing relationships (rhythm) were aberrant in the hearing impaired, when compared with the normals.

15) Normal coarticulatory activity is disturbed in the hearing impaired, is their transition from one syllable to the next is less smooth.

CHAPTER - V

SUMMARY AND CONCLUSIONS

Speech is a form of communication that employs a linguistic code (language) which may be thought of as a systematized code of arbitrary symbols, basically vocal, but reinforced by visible bodily activity. (Gray and Wise, 1946). Continuous speech is the smooth functioning of respiration, phonation, articulation, resonation and prosody or suprasegmentals in an interactive manner.

Suprasegmentals or prosody, which are variations larger than individual segments of speech, include intonation, stress and timing aspects like juncture, duration, rhythm.

Hearing plays an important role in monitoring the production of 3egmental as well as suprasegmental aspects of speech. Impairment in hearing, particularly in childhood, would make it very difficult to acquire and to monitor speech.

The present study was carried out with the aim of investigating the prosodic aspects of the speech of malayalam speaking deaf children.

20 subjects, 5 normal hearing males 5 normal hearing females, 5 hearing impaired males and 5 hearing impaired females, aged between 3 1/2 - 5 1/2 years, were made to narrate the story of the hare and the tortoise, in 8

preformed sentences. All the subjects were native speakers of malayalam language. The samples were recorded, fed into the computer for analysis. As only 6 of the sentences were uttered properly by the hearing impaired, only these six sentences were considered for analysis and comparison. The durational, timing & pausal aspects were measured from the display of the speech waveform. The intonation pattern, and stress, were determined with the help of frequency & intensity curves of each sentence uttered by the subjects. The syllable was considered as the basic unit for analysis.

The list of findings of the present study are as follows,

1) Significantly higher mean speaking fundamental frequency in the hearing impaired females compared to normal hearing females.

2) Overall Higher speaking fundamental frequency in the hearing impaired than the normals.

3) Significantly lower mean intensity in the hearing impaired male than in the normal male.

4) Significantly lower mean intensity in the hearing impaired female than in the normal female.

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6) Locus of stress was varied in the hearing impaired, while it was mainly on the final syllable in the normals.

7) The hearing impaired stressed when on the medial syllable in polysyllabic words, which was not seen in normals.

8) Post-pausal or post-phrasal syllables were more stressed in the normals. This was not seen in the hearing impaired.

9) The intonation patterns of the hearing impaired had an overall similar pattern. However, it was more discontinuous, with poor coarticulation, and greater number of pauses.

10) The frequency showed a gradual lowering throughout the utterance (declination tendency).

11) The rate of speech of the normals was three times faster than that of the hearing impaired.

12) Females in general had greater amount of pauses, though the difference wasn't significant.

13) The hearing impaired had significantly greater amount of pauses than their normal hearing peers.

14) Speech timing relationships (rhythm) were aberrant in the hearing impaired, when compared with the normals.

15) Normal coarticulatory activity is disturbed in the hearing impaired, is their transition from one syllable to the next is less smooth.

IMPLICATIONS:

The normally hearing child obtains skills in parsing connected speech signal via exaggerated & synchronised prosodic cues from caregivers (Jusceyk et al, 1992). The hearing impaired child needs assistance to acquire this information. Early intervention should therefore focus on providing methods of modelling rhythm & timing in accordance with the suprasegmental features of connected speech. As Hird (1995) pointed out, this doesn't preclude modelling of phonemes or syllable, word or phrase boundaries, but rather, the first goals of treatment could be to encourage the infant spontaneously to produce sequences of babbling, with the duration & characteristic rhythm patterns of the native language model. Focussing on 'accurate' production of speech sounds too soon, may 3erve to impede the acquisition of natural sounding speech. Since the overall timing pattern of speech has the potential to provide necessary redundant perceptual cues for any one speech sound, improvements in speech intelligibility could be realized by correcting aberrant durational, aspects of speech produced by hearing impaired speakers.

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