A SYNTHETIC TEST OF RHYTHM

Jayanthi Ray

Reg. No M9110.

This Dissertation is submitted in part fulfillment for Second Year M. Sc. (Speech and Hearing), to the UNIVERSITY OF MYSORE, MYSORE - 6.

All India Institute of Speech and Hearing, Mysore - 570 006.

M A Y 1993

Dedication

To

My Guide,

Parents,

&

Brother.

CERTIFICATE

This is to certify that the Dissertation entitled :

"A SYNTHETIC TEST OF RHYTHM"

is the bonafide work in partial fulfillment for Second Year M.Sc. (Speech and Hearing) of the student with Reg. No. M9110.

Dr. (Miss) S. Nikam
Director,
Ail India Institute
of Speech & Hearing
Mysore - 6.

CERTIFICATE

This is to certify that the Dissertation entitled -

"A SYNTHETIC TEST OF RHYTHM"

has been prepared under my supervision and guidance.

Savithri S.R.

Dr. S. R. Savithri,
Guide.

MAY 1993

DECLARATION

This Dissertation entitied,
"A SYNTHETIC TEST OF RHYTHM"
is the result of my own study
undertaken under the guidance
of Dr. S. R. Savithri,
Department of Speech Science,
All India institute of
Speech and Hearing,
Mysore,
and has not been submitted
earlier at any University for any
other Diploma or Degree.

Mysore
May, 1993

Reg. No.M9110

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In character, in manner,
In style and all things,
Of supreme excellence is
Your simplicity,
Your inspiration,
The serenity of faith,
The wisdom of experience,
The satisfaction of achievement,
Sun of knowledge ,
Fields of flaming vision.
They fascinate me..... .

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My soul is an enchanted boat
Which like a swan does float
Upon the silvery waves.....
On the sea of knowledge.

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To my cutest and dearest brother, **E-Appee-Peeba**:

In every word of courage,
You have given to my need.
I find constant challenge
A special relationship creed

I will remember your constant words of encouragement-
"Roll on and on.... till you conquer the highest and steepest cliffs of success.

To my **parents** --

Out of the depths to the glory above,
You have lifted me in wonderful love.
Blessed is the spirit of mine,
To have you as my parents.

My special tribute to the **Nature** -

The bliss of growth,
The glory of action,
The splendours of achievement,
My life.....
I offer you.

I can hear the words of encouragement in the descending dewdrops. I feel your blessings like showers on new grass. I feel your affection like abundant rain on tender plants.

To **HIM**, my living God, a great transience, my being's boundless atmosphere, my refuge and my strength.

The abode of bliss, wonderously beautiful..... my **home**. I will be attached to you forever.

To my special friend, **Nirmal**.

When my soul journeys into deep solitude....., your love one of the wonderful things in my world, can be just felt by the heart.

You made my heart grow rich
With radiance of joy
With deeds of kindness
With compassion of sorrow
With the fulfillment of love.

To **Mrs. & Mr. Boss !**

Thanks for .....um..m, I am not getting

the right words. Might be, I am having some sort of transient anomia !

To all my **class-mates**, ofcourse special are people like Ella-Meri, Sambar, etc for their discouragement ! Don't get annoyed please.

To **Wipro Genius computers**.

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INTRODUCTION

Prosody or suprasegmentals are properties of speech, that have a domain larger than a single element. As Pisoni & Sawusch (1975) suggest, " Prosody may serve as the interface between low level segmental information & higher levels of grammatical structures in speech.

Haggard (1975) elaborates on this interface role of prosody stating that, "Prosody carries direct phonetic cues to certain semantic & gramatical classes; it therefore serves to restrict the search processes, whereby contact is made between cognitive representation & acoustic representation".

Prosodic or suprasegmental features are linguistic abstraction, which exist in the mind of the linguistically competent speaker-listener. Real time physical events in the acoustic speech signal serve as cues for the perception of prosodic features. The four suprasegments are stress, intonation, juncture & rhythm. Stress refers to the accentuation or emphasis, laid on syllable or word. Intonation refers to variations in pitch as a function of time. Juncture refers to the boundaries between the phonological units, signalled by segmental modifications. Rhythm,

in the conventional usage, refers to the pattern of accents / stress on a string of syllables. The rhythmic pattern, as defined here, is assumed ordinarily to consist of upto seven syllables or so. In general, it has been agreed upon, that there exists some rhythm in speech & that it gives; a shape to a sentence, an idea of the length of a sentence & melody. It also marks the begining & ending of a phrase & helps in memorizing a particular prose or poetry & leads to the ease of pronounciation.

In the past, several investigators, have attempted to explore the prosodic features in various languages. While studies on prosodic features in languages, other than Indian are abundant, those on Indian languages are scarce. Several researchers, (Woodrow, 1809; Fraisse, 1956; Ainsworth 1972; Lehiste, 1977; Martin, 1979; Fant, 1980; Nakatani etal, (1981) have studied rhythm in English. Balasubramanian (1980), Hayes & Lahiri (1991) & Savithri (1991) have studied rhythm in Indian languages. Reference to rhythm has also been made by Sanskrit scholars & in Kannada (Karki, 1986).

If there exists no rhythm, speech breaks down leading to 'dysprosodia'. The sense of rhythm is not properly developed or is disrupted in the hearing impaired, stuttering, cluttering, dysarthria, aphasia &

verbal apraxia. (Schalanger, 1976; Parkhurst, 1978; Stathopoulas 1986 Starkweather 1987). These patients need to be evaluated & rehabilitated for which one needs to know about the development of rhythm. Prosody is intrinsic & critical in both production & perception of speech, & that efficient rehabilitation on other dimensions, must incorporate an understanding of these functions of prosody. It also calls for a test of rhythm. The developmental studies of rhythm, in the literature, indicate that the segmental timing shows a developmental trend in children. By 15 months of age, rhythm starts developing & it continiues till 12 years of age, (Atkinson - King 1973, Keating & Kubraska 1978). Till date, only one test, T-TRIP (Tennesse Test of Rhythm & Intonation) is available (Koike & Asp, 1981) T-TRIP is a three part suprasegmental test. It has twenty five test items. Items for rhythm consists of 1 to 17 in Part I & II. The rhythmic patterns have two levels of stress (stressed / unstressed) & two levels of tempo (regular / quick) for each syllable. However, the T-TRIP has several limitations, one being the inability to achieve an adequate control over frequency. Also, for the perception of rhythm only intensity cues & durational cues are utilized. The cue of fundamental frequency is not considered.

With this test, it is difficult if not impossible,

to evaluate rhythm clinically & provide rehabilitative measures. There is a need to understand the development of rhythm, on the basis of which a test could be formulated. In this context the present study was planned. The aims of the present study were two fold:- (1) to find out the development of rhythm in 2.6 years old to 6.6 years old Kannada speaking normal children & (2) to propose a synthetic test of rhythm. The proposed test, on validation, could be used as a reasonable clinical tool for assessing rhythm as a base for therapy.

REVIEW OF LITERATURE

The literature pertaining to rhythm has been reviewed under the following headings:

I. Definition of rhythm

II. Models of rhythm

III. Functions of rhythm

IV. Isochrony & other rhythm related studies

V. Studies on rhythm in Non-Indian languages & Indian languages

VI. Tests on rhythm

VII. Development of rhythm

I. DEFINITION OF RHYTHM :-

"What a tangled web we weave.....", Hamlet's statement aptly describes the literature that has attempted to provide definition of relevant terminology. The study of suprasegmentals & prosodic features is not lacking in descriptive terms, but is lacking in agreed upon definitions of these terms. Consequently, most people rely on a traditional definition of rhythm as the pattern of beats within a

strict metric scheme, a definition, that is too restricted for Understanding the rhythm of speech. There are two prosodic features which describe the temporal chracteristics of a spoken utterance: tempo & rhythm. Tempo is the rate at which utterance is spoken & rhythm of an utterance is the pattern of time intervals which elapse between the occurrence of stressed syllables.

Rhythm is derived from a Greek word 'Ruthmos', where 'rhu' means flow. Rhythm is defined as a pattern of movements which occur with more or less temporal regularity. Rhythm is a certain swing or balance in bodily movement, music or verb or phrase. [Encyclopedia Britanica, 1965]

In Sanskrit literature, 'rhythm' is a measure of time. The term 'rhythm' means metrical movements, determined by various relations of long & short or accented on unaccented syllables. Lashley (1951) assigned great importance to rhythm & suggested that rhythm is a substratum for virtually all perceptual & motor activities. Rhythm may be defined as a temporal patterning. Hrushvsky (1960) writes on the subject of poetic rhythm for eg, "We can observe many rhythmic factors : metrical sequences & deviations from their ideal norms, word boundaries & their relations to feet

boundaries, syntactic relations, word order, synatactic tensions, repetitions & juxtaposition of sound, meaning, elements, etc. Practically, everything in the written poem can contribute to the shaping of the rhythm."

Rhythm may be broadly defined as the "structure of a sequence". (Allen 1975). This definition has two implications, first it establishes rhythm as a structure, which can therefore be understood only as a relationship or a set of relationships among the units, making up that structure. Second, it deliberately leaves open what those units are; they can be features segments, syllables, words, phrases or paragraphs or even sneezes or total eclipses of the moon - all that is important is that they occur in a sequence. Even, the role of time is de-emphasized in this definition of rhythm, for although time is necessary for both the production & perception of a sequence, if the structure of the sequence, that defined it's rhythm & time is the only one of the several possible components of that structure.

II. MODELS OF RHYTHM :-

There are at least three models of rhythm:-

(1). Comb model (Kozhevnikov & Chistovich, 1965)

(2). Chain model (Kozhevnikov & Chistovich,1965)

(3). Isochrony model. (Abercrombie, 1965)

According to the comb model, the units of speech are executed according to some underlying programmed time schedule. Preprogramming is akin to open-loop control, in that, the control exercised, in the system, doesn't rely on the output. Preprogramming may also be defined as a set of commands that are structured before a movement sequence begins, & that allows the entire sequence to be carried out, uninfluenced by peripheral feedback. (Keele, 1968).

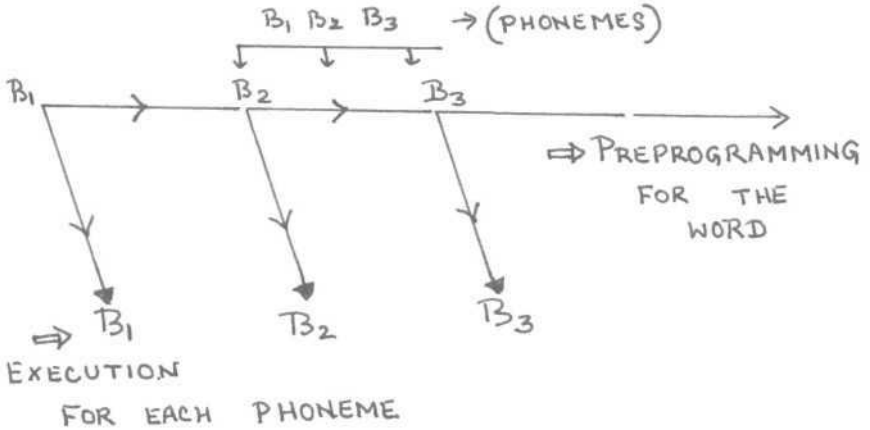

Fig. 1 :- COMB MODEL

According to the chain model, there is no underlying time program or rhythm; a given speech gesture, simply is executed after the proceeding time

program or rhythm, A given speech gesture simply, is executed after the preceding gestures have been completed successfully. A chain model is for long term timing & the comb model is for short term timing. (Bernstein, 1967). A chaining strategy for motor sequencing assumes that the performance of any of a series of movements depends upon feedback, regarding the accomplishment of a preceeding movement. The chain model is depicted in Fig 2.

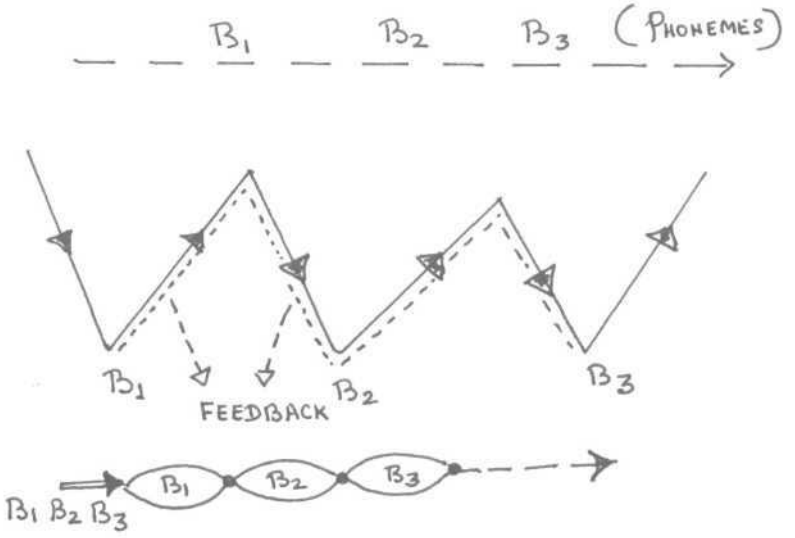

Fig.2 – CHAIN MODEL

Kozhevnikov & Chistovich (1965) elaborated a model of speech production that incorporates syllabic units in a rhythmic sequence, called a syntagma, which has an average length of about seven syllabes. Kozhevnikov claims that "only sequences of syllable commands are rhythmically organized; individual movement within a syllable which provide for the transition from

consonant to vowel, adhere to their own intrasyllabic laws. They wrote, ". . . . the rhythmic figure (pattern) actually exists as some independent sign of a word (phrase) & . . . consequently, it is necessary to assure the presence in the nervous system of special set-ups (groups of interrelated neurons) which provide for the generation of complex rhythmic sequences. They regarded the basic elements for speech programming to be simple CV combinations & suggested that more complex combinations (eg CCV, CCCV) & merely CV groupings assembled so that certain CV units begin before the preceeding CV unit is complete.

In the 'isochronous foot model', the first syllable in each foot is a stressed syllable. If the model is correct, the duration of every foot will be equal. This is depicted in Fig 3. The rhythm of an utterance is the pattern of time intervals which elapse between the occurrence of stressed syllables.

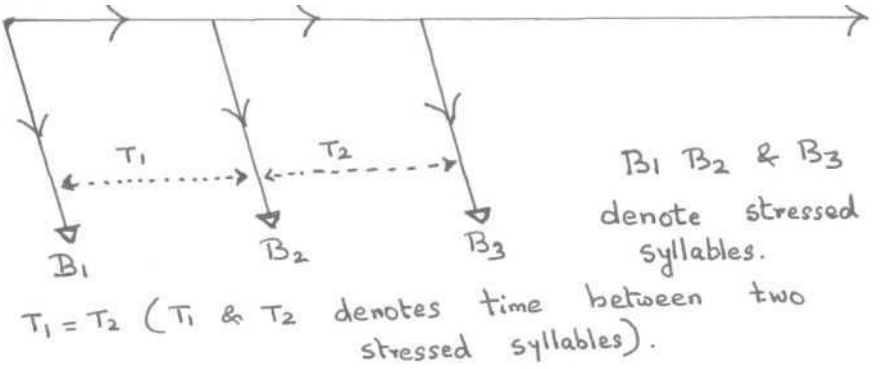

Fig. 3. - ISOCHRONOUS FOOT MODEL

III FUNCTIONS OF RHYTHM:-

There is a tendency to speak out languages with fairly regular time/rhythmic unit, each of which has a strong prominence. These rhythmic units may be composed of different number of syllables. Syllables of longer units are spoken more rapidly than those of shorter units. Such rapid speaking of long syllables results in weakening & unstressing of the less important syllables & changes in the sound values of the vowels of such syllables. The pauses after rhythmic units may be increased or decreased. These shorter or longer pauses, when combined with rapidity or slowness with which we speak our phrases, help make the isochronic nature of our languages noticeable. Continuity, rate & rhythm have traditionally been considered as aspects of speech timing. Rather than being a dimension of fluency, rhythm tends to promote/enhance fluency. It does this in several ways:- Unstressed syllables are shorted & thus require less time. In addition, rhythm assists in rapid speech production, by providing a means for us to anticipate upcoming movements. Martin (1972) says, " . . . . the perception of early events in a sequence generates expectancies concerning later events, in real time. When the events are sounds produced by continuous movements, the perception of these, includes

cues as to the movement dynamics, involved in their promotion".

Hence it is not simply, or not only that discreet arrival times of accented syllables are induced from earlier timing relationships but also that the total array time - varying cues in the continuous flow of speech, will project ahead the general outline of the remaining prosodic contour. These cues telegraph not only temporal changes, but more generally, the whole thrust of pattern of sounds yet to come. It is on this basis, that one might say not that the listener "follows" the speaker, but rather than the listener, given initial cues, actively enters into the speaker's tempo. Rhythm helps the speaker to produce speech more quickly & also enables the listener to decode speech more quickly. It is surprising for many people to learn that the movements of listeners tend to be in synchrony with the syllabic rhythm of speech, produced by someone who is talking to them. The listeners body seems to respond to the rhythm of the speakers words, almost as if in a dance.

The role of the rhythm in promoting fluency, cited by Bruner(1973) as a criteria of motor skill learning was speed, efficiency & anticipation. Rhythm of speech is special in two ways. First, it is not a strictly

regular beat & sound, the tempo of rhythm changes during utterances, in relation to word & clause boundaries. Speakers are able to follow rhythm, using them to anticipate & produce temporarily accurate speech movement, as the tempos of the rhythm increase or decrease. Capacity for fluency comes from rhythm. Although, little is known about it, it is easier for a child to anticipate the movement of speech & will give a sense of metric confidence, similar to the confidence, a well practitioned athelete or musician feels, when performinig a task with superior skill.

IV. ISOCHRONY & OTHER RHYTHM RELATED STUDIES:-

The term 'isochrony' refers to the phenomenon that in a stress timed language, such as English, stressed syllables follow each other at approximately equal time intervals. (Pike, 1945) Isochrony is a term, used for speech rhythm which refers to a patterned time program, underlying the sequences of speech. Two types of rhythmic patterns are found on isochrony:

(1) Stress timed isochromy.
(2) Syllable timed isochromy.

In stress-timed languages, the stressed syllables follow each other at approximately equal time intervals. Eg: English. In syllable timed languages,

the syllables follow each other at regular time intervals. Eg: French (Lehiste, 1977, Nakatani et al l981). Several experiments have been conducted to find out isochrony in speech. While, the result of some experiments (Halliday, 1967; Higgins, 1972; Allen, 1972, 73; Lehiste, 1973, 1975) support the concept of isochrony some like Classe (1939), Shen & Peterson (1962), Bolinger (1965), O'Connor (1965) do not. It has been opined that there might not be a stricit isochrony in a physical sense.

V (a). STUDIES ON RHYTHM IN NON-INDIAN LANGUAGES.:-

Zlatoustova (1975) studied rhythmic structure types in Russian speech & found that rhythmic structure classes composed of two & three syllables which were most frequent & the distribution of rhythmic structures according to position of stress was far from immaterial. Hill etal (1977) studied the underlying causes of rhythm in spoken British English. It was found that although, there was some tendency towards isochrony accounted for at most 10% of the duration structure of the rhythmic units.

Martin (1979) studied about the rhythmic segmental perception. Thirty-Six basic sentences which

were six-syllable nonsense sequences of (a) Either vowel in the sentence was lengthened on shortened by about 50, 90 or 130 msec by computer editing routines. (b) the sentence was intact. The result indicated the following: (a) Tempo change effects were ubiquitous. For instance, vowel changes in the first syllable increased reaction time to targets in their later syllables. (b) Both vowel shortening or lengthening increased the target reaction time. (c) Effects attributed to processing time decreased, whereas effects attributed to stimulus expectancy increased, with time into the sentences. (d) Tempo effects persisted throughout the experiement. It was concluded that the effect of time distortion of the stimulus on target reaction time were produced, mainly by changes in stimulus-included expectancy, & not changes in processing time. The expected input to perception was the acoustically intact utterance in both its rhythmic & segmental aspects, these aspects were not perceived independently.

Pointon (1980) stated that Spanish has no regular rhythm in the sense of an isochronous sequence of similar events, be they syllables or stresses, but that there is some form of segment timing, in which the number & type of segments in each syllable, together

with the presence or absence of stress, determine the duration of a syllable.

Nakatani etal (1981) studied American English speech rhythm using reiternat speech with the prosody of normal speech but without its segmental variations. It was found that syllable duration was strongly influenced by stress and by final positions in words and phrases, but negligibly by nonfinal positions within words and phrases. No isochrony was, however, found.

Roy (1981) presented in his paper, an instrumental & phonological evidence that Brazilian Portuguese has a tendency towards stress timing. The evidences were as follows:-

(1) Interstress durations are not directly proportional to the number of syllables.
(2) Many differences in interstress durations are not perceptible.
(3) Syllable duration is inversely proportional to the number of syllables in a word.
(4) In causal speech, unstressed syllables are deleted, which has the effect of equalizing the number of syllables in each stress group.

(5) Shorterning processes, which reduce duration, have the effect of aiding stress - timing.

Wioland etal (1982) studied French language & rejected the notion of syllable timing for French. French syllables are produced & perceived in rhythmic groups, just as those of English. However, what serves to establish rhythmic groups in French, is a lengthening of what is perceived as final syllable in each group, whose vowel is generally unmarked by any intensity increment. For this reason, it was proposed to characterize French as being trailer - timed.

Miller (1984) described an experiment which attempted to determine the degree of consensus, if any, on the perception of syllable/stress-timed rhythm in eight languages - Arabic, Polish, Argentinian, Spanish, Finnish, Japanese, Indonesian & Yoruba. Recorded language samples in reading & conversational styles were presented to English & French phoneticians & English & French non phoneticians. Results indicated that Arabic was strongly stress - timed, Spanish and Yoraba clearly stress - timed &

while Japanese, Finnish & Indonesian were not clearly assigned to either rhythmic type. Categorization of Polish was difficult. Even so, languages appear not to fall clearly into dichotomous

rhythmic types, but to display features of both types in different proportions.

Dauer (1983) studied stress & syllable timing & compared data from continuous texts in English, Thai, Spanish, Italian & Greek. The results show that interstress intervals in English, a stress timed language, are no more isocronous than interstress intervals in Spanish a syllable timed language, or any of the other languages, investigated. A tendency for stresses to recur regularly appears to be a language universal property. The difference between stress-timed & syllable - timed languages has to do with difference in syllable structure, vowel reduction and the phonetic realization of stress and its influence on the linguistic system. Languages, language varieties or historical stages of a languauge can be considiered more or less stress-based, depending on differences in these characteristics. It seems likely that rhythmic regrouping takes place even in languages which have been called syllable - timed.

Lehiste (1985) did a study on rhythm of poetry & prose. This study was undertaken in order to tap the rhythmic structure of spoken language & the metric structure of poetry. The difference between the

rhythmic units used in English prose & poetry is not really very great. The trochaic feet that were in the focus of this study appear to be realized in very similar ways, regardless of whether the materials are produced as poetry or as prose. Perhaps, this was an indication that even though poetic form superimposes a set of rhythmic constraints on spoken languages these constraints operate within the possiblities provided by the suprasegmental structures of the language.

Williams (1986) examined some features of Welsh prosody & found that stressed syllables occur at approximately equal intervals. When the penultimate syllable was counted as stressed, a greater tendancy towards isochromy was observed than if the more intrinsically final syllable was counted as stressed.

The temporal aspects in spoken English was tested by Brad etal (1987) and found that once a stressed syllable has been finally lengthened , the tiny shortening effect of an unstressed syllable, across a word boundary does essentially nothing to preserve isochromy among feet. A stress timing tendency was noticed in English.

The natural rhythmic patterns in English verse were examined by Kelly etal (1988)and he gave evidences from children's performances in counting out rhymes. It was found that the rhythm of counting out rhymes is constrained by the principle of rhythmic alternation, the nuclear stress & compound rules & foot boundaries.

Fant etal extensively studied the language specific patterns of prosodic & segmental structures in Swedish, French & English, Processing on duration of syllables & phonemes in stressed & unstressed positions. In French, they noted a finite amount of stress - induced segmental lengthening at phrase internal locations, which is less prominent than phrase final prepausal legthening. All these parameters were smaller in French as compared to Swedish & English. If compared on the basis of the same number of phonemes per syallable, the stress - induced lengthening is less in French than in the other two languages. They referred to French as "syllable - timed" and Swedish & English as "stress - timed" & postulated that the stress timing is not a matter of physical isochrony of interstress intervals, but a perceptual dominance of heavy syllables, the succession of which is sensed quasi-periodical. A language is sensed as syllable-timed, when these stress cues, including contrasts in syllable complexity & precision are reduced.

The stress pattern, pause & timing in prose reading were investigated by Fant etal (1989). Perfect synchrony in pause realization was found in relaxed rhythmical reading only. In rhythmical reading, stress timing preserved synchrony across pauses in terms of one/more extra rhythm units, added to the boundary. These units were the time intervals of an internalized clock which followed a relative short time average of interstress intervals, already executed & perhaps also, those that were just about to be executed. Stress rate was found to be conditioned by the text & exerting an influence of the criteria of rhythmicality, in pause planning. Pause & final lengthening were similarly structured in music & in speech.

Fant etal analyzed the reading of word lists, conforming with the text. The degree of durational reduction in connected speech, compared to the isolated words varied with the particualr word class & allowed a hierarchical ordering of content & function words. Stressed syllables tended to expand more than unstressed syllables in a change from vowel to a distinct reading mode.

Garding etal (1989) studied Swedish prosodic phrase patterns. Two double peaked prosodic phrase patterns (a) with two even accents. (b) With accented

followed by deaccented, were used in an experiment, in which the second peak was shifted in steps of 20 msec in a third category, a compound phrase was created. The stimuli were presented to the listeners. Results indicated that pitch movements over the vowels were powerful cues for identification & also the spectral & temporal characteristics were important.

Farnetani (1990) studied the temporal structure of Italian noun phrase sentences & found that the degree of prominence decreased from stressed vowels in nonfinal words, to rhythmically accounted unstressed, to accented unstressed vowels. This investigation contributed to the perception of Italian as a syllable - timed language.

In French, it was found that the accented syllables at the edge of intonational phrases were longer than phrase interval accents, & a less clear - cut durational contrast was found, (Fletcher,1991). Cutler etal (1992) studied rhythmic cues to speech segmentation & provided evidences from juncture misperception. It was found that there was an insertion of a word boundary before a strong syllable & deletion of a word boundary before a weak syllable. Also, boundaries inserted before strong syllables

produce lexical words while boundaries inserted before weak syllables produce grammatical words.

V STUDIES OF RHYTHM IN INDIAN LANGUAGES.

Balasubramaniam (1980) investigated rhythm in Tamil and postulatled that Tamil can be called neither stress-timed nor syllable timed. Tamil can't be called a stress-timed language in that stressed syllables do not tend to occur at regular intervals of time. If by stress-timed language, it is meant that it takes one unit of time to utter one unstressed syllable between two successive stressed syllables, 3/4/5 unstressed syllables between two stressed syllables should take the same unit of time, Tamil is clearly not a stress - timed language. Tamil can't be called syllable - timed language, either, because if by this term, it is meant that syllables should occur at regular intervals of times, it doesn't appear to be so. There was of course some found in the duration of syllables of particular structures in Tamil.

Savithri (1991) studied rhythm in Kannada language. The result indicated that two feet occured maximally followed by three feet and one foot. One of

the perceptual corelates was equal timing, which was identified by 27% of the subjects. However, the results gives little support to the theory of isochrony.

VI TESTS OF RHYTHM

The Tennessee Test of Rhythm & Intonation Patterns (T-TRIP) was developed by Koike & Asp (1981). It is a three part suprasegmental test with 25 items. The test items consists of the nonsense syllable /ma/ that was spoken and recorded with different rhythm and intonation patterns. The symbols in Fig.4. identify rhythm (for example, stressed to unstressed for Item 1) and intonation (from item no. 18 to 25). Musical notations were used to indicate the appropriate tempo. The rhythmical patterns had two levels of stress (stressed or unstressed) and two levels of tempo (regular or quick) for each syllable. Since stressed syllables usually have a higher pitch (Fairbanks, 1940, Lehiste, 1970), the stressed syllable was designated as high pitch (top line) and the unstressed syllable as mid pitch (mid line). Each syllable was identified as by a single dot (a large dot for a stressed syllable and a small dot for an unstressed syllable. For Part I, the rhythm section, - test items 1 - 14, - had 2 - 6 syllables (/mal/) that varied in stress and tempo. In

part II: - item 15, 16, & 17: - the tempo increased 1 - 3 syllables per beat and this produced 3 - 9 syllables. Ten three-year olds and ten five-year olds imitated the pattern they heard. The five - year olds scored significantly better then the three - year olds. The T-TRIP also appears to be sensitive to differences between groups of different ages. Fig 4 depicts the rhythm part of the T-TRIP test.

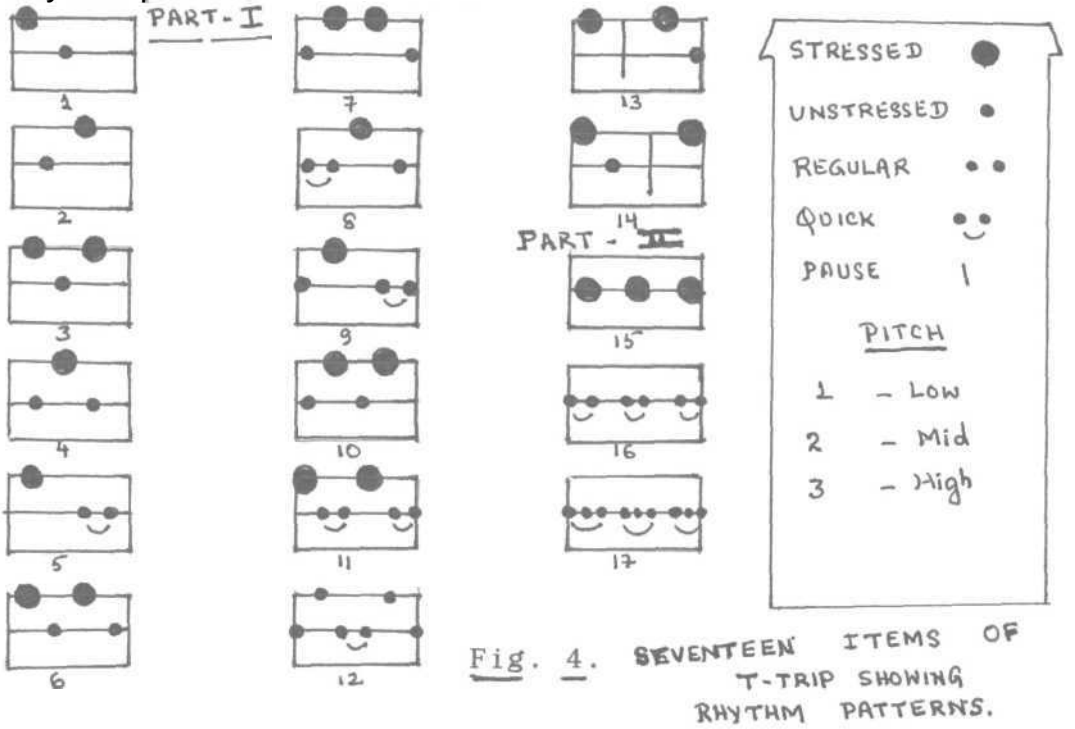

Fig. 4. SEVENTEEN ITEMS OF T-TRIP SHOWING RHYTHM PATTERNS.

Benguerel etal (1986) studied time - warping and the perception of rhythm in speech. Four tests were constructed in which each stimulus consisted of a sequence of Six clicks or Six syllables, each test containing time - warped stimiuli. Time - warping was non-linear & progressive. Native speakers of English, French and Japanese were asked to rate the sequence as

accelerating, regular or decelerating. Results indicated that for a range of parameter values of the time - warping parameter, stimuli were perceived as regular. Most of them were decelerating acoustically.

VII DEVELOPMENT OF RHYTHM.

Phonological rhythm is the combined result of a number of concurrent sequential phonological processes, involving not just the time intervals between syllables & stresses, but also the very nature of syllables and stress as well as a host of other phenomena.(Hrushovsky, 1960). Ingram (1974), Moskowitz (1970), Smith (1973) & Waterson (1970) suggest that rhythm of very young children's speech will be syllable-timed, since early polysyllabic utterances are composed largely of reduplicated or partially reduplicated forms that are themselves short sequences of phonologically similar, unreduced monosyllables. By the age of 4 or 5, the rhythm becomes more adult like, with increased rate of a greater number of reduced nuclei. These data also fit well with the presenting emerging views of relationship between the stress, rhythm & perceptual processing of speech. Table - 1 summarizes the development of speech rhythm in children.

Author & Year	Method / task	Findings.
Moskowitz(1970)		Children omit the initial weak syllable in a polysyllabic word.
Fonagy(1972)	Acoustic correlates of one & two phrases of children.	The earliest two word stages had parallel pitch movement. In later utterances, final accented syllables were of greater durations & the non-final syllables had upward pitch movements.
Atkinson-King (1973)		At the age of 12 years, children perceive & produce stress like adult manner.
Kirk(1973)	Tested the relative strength of rhythmic versus tonal versus segmental constraints in children's speech.	Tone was repeated most accurately, segments least accurately, with rhythmic accuracy lying in the intermediate.
Smith(1973)		Children omit the inital weak syllable in a poysyllabic word.
Disimoni (1974)		The average duration of both vowels & consonants decreases as children grow, suggesting that the child's accuracy & ability to control the timing of speech improves with age.
Hawkins (1974)	Studied 4-7 year old children & followed them up after 14 months.	Durational developmental trends were evident.
Ingram (1974)		At one-two word stages of development,children do not produce syllable sequences with stress contrast, sub-stituting stressed for un-stressed syllables.
Eilers (1975)	Sentence imitation task in 18-36 month old children.	Children's syllables will change in their relative durations as accent related rhythmic patterns mature, since durational differences are both perceptible & important to the young speaker.
Keating & Kubraska (1978)		Smaller durational differences between first & second syllables in the words, spoken by a single subject from 15 months to 28 months.
Yairi (1981)		Children start acquiring speech rhythm at the age of two to three years.

TABLE 1 : DEVELOPMENT OF SPEECH RHYTHM IN CHILDREN

To summarize, the results of these studies indicate that the segmental timing shows a developmental trend in children and that the children start to develop speech rhythm as early as 15 months, which continues till the age of 12 years. However, the methodological difficulties have restricted the number of studies on the development of speech rhythm as a result of which thorough investigations has to be done in this area. In this context, the present study is planned, the aim of which is to study the development of speech rhythm in Kannada speaking normal children in the age range of 2.6 - 6.6 years by using a synthetic test for rhythm.

M E T H O D O L O G Y

MATERIAL:- In order to study the nature of developmental trends in rhythmic patterns, the syllable /ma/ was chosen as a stimulus, as it is acquired relatively earlier than other syllables (Jacobson, 1971; H alle, 1968; Menyuk, 1972 & Tasneem, 1976). However, due to nonavailability of the nasal shunt, tube, as an accessory for the synthesis of nasal sound in the synthesizer, the syllable /ma/ was replaced by its closest counterpart /ba/, the voice bilabial plosive. The syllable /ba/ was synthesized for a duration of 500 msee at a sampling frequency of 8000 Hz & a resolution of 10 msec, using the program CRT, developed by voice & speech systems Bangalore. The acoustic parameters, used to generate the syllable /ba/ are depicted in Table 2. The first formant (F1) was kept steady for 80 msec at a frequency of 0hz & a smooth transition was introduced from 90 to 120msec & from 120 to 500msec a steady value of 750 hz was introduced. The second formant (F2) was zero till 90 msec & from 90 too 120msec, it increased to 1250 Hz & from 120 msec onwards, it was kept constant at 1250Hz, till the end. The third formant (F3) was zero till 90msec, & was transited to 2200hz at 120msec, which was kept steady till the end. The bandnidths had constant values of 100, 200, & 300Hz for the first, second & third formants respectively. The fundamental

frequency of the stimulus was at 120Hz for the duration from 0 to 80msec & was raised to 140Hz at 120mSec, which was maintained till 450msec from 400msec onwards, fundamental frequency declined gradually to 100Hz till the end.

The intensity of the stimulus was kept at zero at the onset of the stimulus & at 10msec, intensity was raised to 600RdB which was kept steady; till 80msec. Between 80 to 90 msec, the intensity was increased to 657RdB in order to introduce a burst. At 90msec, the intensity value was decreased to 600RdB & at 100msec, the intensity was increased to 600RdB, which was kept steady till 500 msec. From 400msec to 500msec, intensity was gradually reduced to zero. Fig 5 shows the spectrogram of /ba/. The method of reiteration was used to generate rhythmic patterns, which were based on a study in Kannada by Savithri (1991). Rhythmic patterns, starting from one foot to six feet were generated. One foot referred to stress on each syllable, two feet referred to stress on alternate syllables, three feet referred to a stressed syllable, followed by two unstressed syllables & four feet to a stressed syllable, followed by three unstressed syllables & so on. The construction of rhythmic patterns were based on Fant's notion, where a meter is a sequence of recurrent feet in a regular pattern. Every metrical foot contains one strong syllable or

beat or one or more weak syllables & rhythm is a regular altlernation between stressed (strong) & unstressed (weak) entities. In this study, the relative strength factor of the syllable /ba/ was generated in three ways:- viz, by altering the fundamental frequency, by altering intensity & by altering both fundamental frequency & intensity. Fundamental frequency was reduced in 5Hz steps & intensity was reduced in 100 RdB steps.

----> Duration - (msec)--->

Parameters	0 - 80	80 - 90	90 - 120	120 - 400	400 - 500
F1 (Hz)	0		Transition	750	750
F2 (Hz)	0		Transition	1250	1250
F3 (Hz)	0		Transition	2200	2200
F0 (Hz)	120		Transition	140	140-100
I (RdB)	0-600	657	Transition	800	800-0

Table - 2 Acoustic parameters, used to synthesize /ba/.

Table 3 depicts the details of the intensity & frequency of all the syllables, generated. From the

above syllables, rhythm patterns were generated. One foot consisted of one strong syllable /ba/. Two feet comprised of one strong syllable, followed by a weak syllable, etc. The rhythm patterns were synthesized by concatenating the respective syllables, using the program, FADD (voice & speech system, Bangalore). Six stimuli, each in altered frequency Intensity & five stimuli in altered intensity & frequency (both varied together) were synthesized. Thus, a total of seventeen stimuli were synthesized for the study. Using the program, 'DISPLAY' (voice & speech system, Bangalore), these stimuli were replicated to make two distinct units & a silence of 500 msec, was introduced between the first & second units, in order to be perceived as different units. Thus, task 1 consisted of six rhythmic patterns, where the strength of syllables referred to intensity only. Task - 2 referred to the variation of fundamental frequency alone & task - 3 consisted of syllables, where the strength was determined, both by frequency & intensity. All these synthetic stimuli were audio-recorded, using a 12 bit D/A converter on to a metallic cassette, with an interstimulus interval of one second. These synthetic stimuli formed the material. This is depicted in Fig 6.

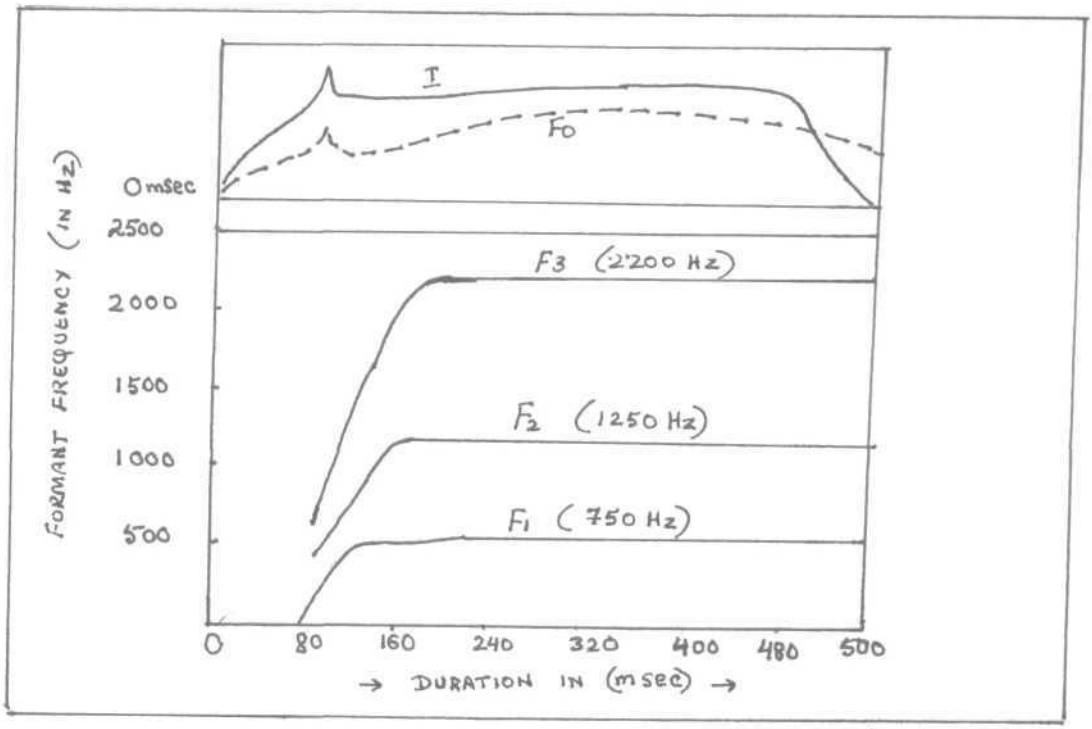

Fig. 5. SPECTROGRAM OF /ba/

	0-30 msec.	90-120 msec.	120-400 msec.	400-500 msec.
Strong (FO Levels)	120	120-140	140	140-100
Syllable (I levels)	0-600	600-800	800	800-0
Weak FO	115	115-135	135	135-95
syllable I	0-500	500-700	700	700-0
weak FO	110	110-130	130	130-90
syllable I	0-400	400-600	600	600-0
Weak FO	105	105-125	125	125-85
Syllable I	0-300	300-500	500	500-0
weak FO	100	100-120	120	120-80
syllable I	0-200	200-400	400	400-0
weak FO	95	95-115	115	115-75
syllable I	0-100	100-300	300	300-0

Table - 3 shows the details of the intensity and frequency of syllables.

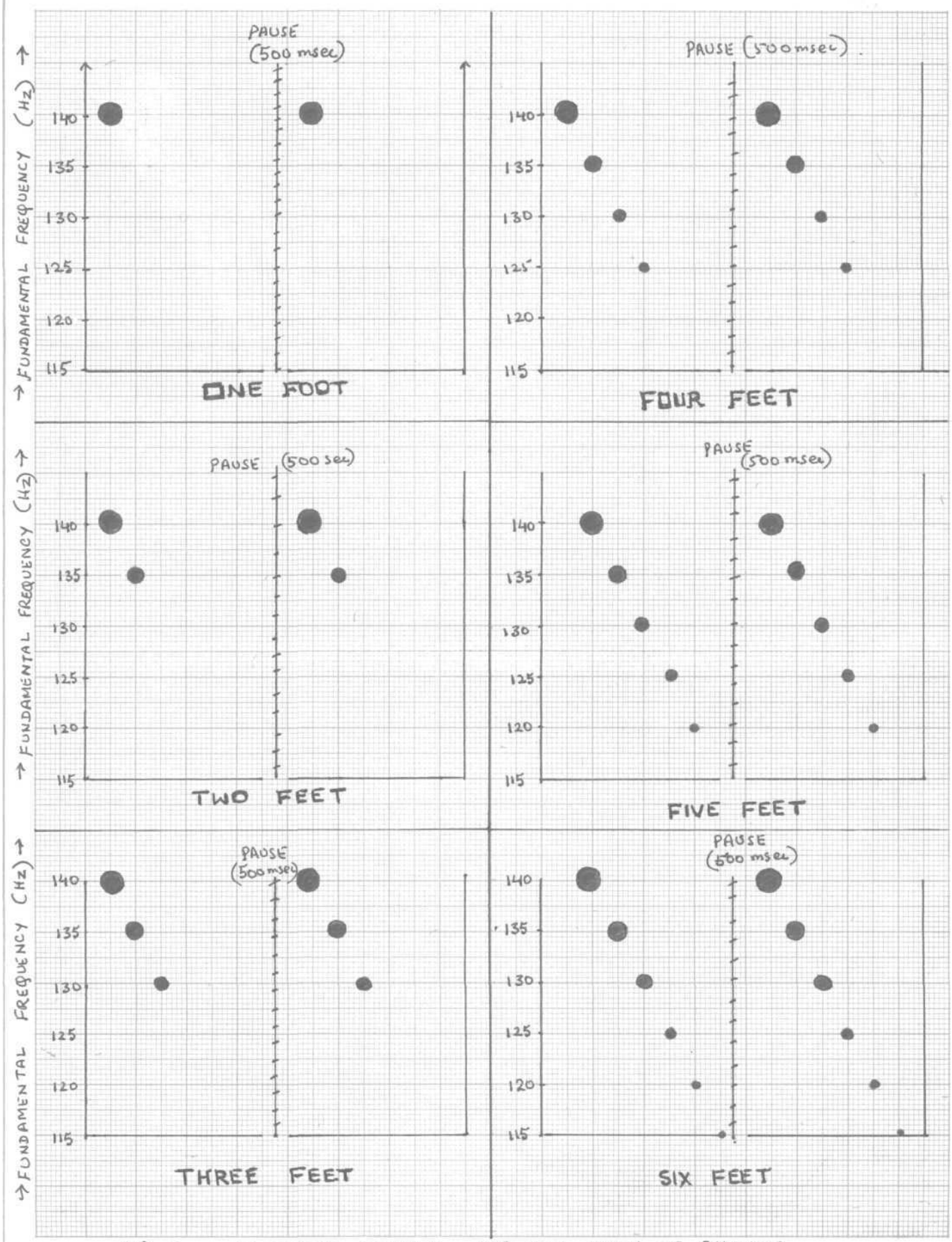

FIG. 6. SYNTHETIC STIMULI FOR THE TEST OF RHYTHM.
THE ABOVE FIGURE HOLDS TRUE FOR INTENSITY TOKENS & INTENSITY AND FUNDAMENTAL FREQUENCY TOKENS.

Following the construction of test material, two experiments were carried out. Experiment I was the Identification of Rhythm Patterns by Adults & Experiment II was 'Perception of Rhythm Patterns by children'. In the first experiment, all the seventeen synthetic stimuli were used & following the results of Experiment I, synthetic stimuli were selected for Experiment - II.

EXPERIMENT - I IDENTIFICATION OF RHYTHM PATTERNS BY ADULTS.

SUBJECTS:- Twenty Kannada speaking normal speech pathologist & Audioiogists (ten males & ten females) trained in perceptual judgement in the age range of 18 - 25 were selected as subject. Their hearing levels were within 0 - 25 dBHL - (ANSI - 1969).

METHOD:- The subjects were individually tested. Ail the seventeen synthetic stimuli (models) were audio-presented one at a time to the twenty subjects through tape recorder in a quiet room, & they were instructued to listen to each stimulus & imitate the stimulus. They were allowed to listen to each stimuli, at least three times. These imitations were audio-recorded on a cassette for further analysis.

ANALYSIS:- Two judges evaluated the imitations. The judges were instructed to carefully listen to the model & imitation & write 'same'/'different' depending on the perception. The response, 'same' was scored 'one' & the response, 'different' was scored 'zero'. The total number of 'same' was calculated & the percentage of this, was computed seperately for the three tasks by the following formula:-

$$\frac{\text{Total score obtained for each synthetic stimuli for all the subjects}}{\text{Total possible score obtained by two judges (40)}} \times 100$$

'T' test was applied to find out the significant difference between the mean of the scores of the experiments. Rank correlation method was adopted for measuring the interjudge reliability.

EXPERIMENT - II PERCEPTION OF RHYTHM PATTERNS BY CHILDREN

Subjects:- Forty Kannada speaking normal children in the age range of 2.6 - 6.6 years with 10 children each in one year range interval (2.6 - 3.6, 3.6 - 4.6, 4.6 - 5.6 and 5.6 - 6.6) were selected for the study. Each age group had five male and five female

children. All the children reportedly had normal hearing and normal speech and language, as per the evaluation of the experimenter.

METHOD : Based on the results of Experiment - I, the stimuli were selected for children. Analysis of responses indicated that the stimuli, one foot, two feet, three feet and four feet were imitated correctly and it was difficult for the adults to imitate five feet and six feet. So the children were presented only till four feet in each of the experimental paradigms. Each child was tested individualy in a room, free from external noise. Four to six practice trials were given to each child for a familiarization of the stimuli. The children were audio-presented with one stimuli at a time and were instructed to imitate the stimuli. The stimuli were replayed for three times, when needed. All the imitations were audio-recorded on a cassette. Two speech pathologists analysed the imitations. The scoring system was same as in Experiment I. Rank correlation method was applied to find out the corelation between the two judges and the data were tabulated and graphically represented in order to tap the developmental trends of rhythm in children. Also, the 't' test of significance was applied to find out the significant differences between the means of each group, under study.

RESULTS

RESULTS :-

Experiment 1 - Identification of Rhythm Patterns by Adults.

Table 4 shows the percent response for each stimulus. The results indicate that five feet and six feet stimuli could not be imitated by adults. Compared to Task-1 and Task-2, Task-3 was better in that, in Task-3 Stimulus-5 was imitated at least by 12.5% of the subjects. Percent response for one foot, and two feet were maximum, followed by three feet and four feet. On the basis of these results,

only stimuli till four feet were chosen for Experiment-II and stimuli with five feet and six feet were deleted.

Task 1

(Intensity Token)	Percent response (Judge - 1)	Percent response (Judge - 2)	Average response
1 foot	100	100	100
2 feet	100	100	100
3 feet	25	35	30
4 feet	10	5	7.5
5 feet	0	0	0
6 feet	0	0	0

Task 2

(Intensity Token)	Percent response (Judge - 1)	Percent response (Judge - 2)	Average response
1 foot	90	95	92.5
2 feet	55	65	60
3 feet	25	25	25
4 feet	15	5	10
5 feet	0	0	0
6 feet	0	0	0

Task 3

(Intensity Token)	Percent response (Judge - 1)	Percent response (Judge - 2)	Average response
1 foot	85	95	90
2 feet	75	80	77.5
3 feet	50	60	55
4 feet	15	25	20
5 feet	10	15	12.5

Table 4: Percent reponse for various stimuli (in three tasks) in adults.

Table 5 shows the raw scores, average percentage scores in each task and the overall percentage on all the tokens. The performance level in task-3 (intensity and fundamental frequency tokens) was better.

Subjects	Judge 1			Judge 2			Average % Scores			Overal1 % Scores
	Task1	Task2	Task3	Task1	Task2	Task3	Taskl	Task2	Task3	
1.	1	1	3	3	3	4	33.3	33.3	70	41.1
2.	1	1	1	2	0	3	25	8.33	40	23.52
3.	2	1	0	2	1	3	33.3	16.6	4.6	35.24
4.	2	3	0	1	3	2	25	50	20	32.35
5.	1	0	1	0	0	0	8.33	0	0	2.9
6.	2	1	2	1	0	0	25	8.33	10	14.7
7.	2	4	3	3	2	4	41.6	50	60	50
8.	2	1	3	1	1	1	25	16.6	40	26.47
9.	2	2	1	2	2	2	33.3	33.3	50	38.23
10.	1	0	3	1	0	0	16.6	0	0	5.6
11.	2	2	3	1	1	3	25	25	60	35.24
12.	3	2	3	4	2	3	68.3	33.3	60	50
13.	3	2	2	3	2	2	50	33.3	40	41.17
14.	1	2	2	3	2	2	33.3	33.3	40	35.24
15.	1	2	2	2	2	3	25	25	50	32.35
16.	4	3	4	3	3	5	58.3	50	90	64.7
17.	3	4	5	2	3	5	41.6	58.3	100	64.7
18	4	4	5	3	4	5	58.3	66.6	100	73.52
19.	1	1	2	2	2	3	25	25	50	32.35
20.	1	2	3	2	2	3	25	33.3	60	38.23
							33.3	35.8	47.23	36.89

Table - 5 : Raw scores, average percent scores and the overall percent scores.

Note :- Task - 1 - Intensity Tokens.

Task - 2 - Fundamental Frequency Tokens.

Task - 3 - Intensity and Fundamental Frequency Tokens.

Table 6 indicates the results of significance of the difference between the means of the three tasks, amongst the adults. The difference between means of responses of task-1 and task-2 was not significant (0.05 level). However a significant difference between the mean performances in task-2 and task-3 was noticed at 0.01 level. Also, a significant difference between the mean performances of task-1 and task-3 (at 0.01 level) was present. The results indicate that the performance of subjects in task-3 was significantly higher than that in task-1 and task-2. This suggests that a combination of frequency and intensity could provide a better cue for the subject to identify the rhythm.

Tasks	Result of significance
Task 1 vs 2	Not significant at 0.05 level
Task 2 vs 3	Significant
Task 3 vs 1	Significant

Table - 6: Significance of difference between the means of three tasks in adults.

Table 7 shows the corelation coefficient (r) among the scores obtained by two judges in all the three tasks and the overall test. The values of high r indicate good interjudge reliability.

Table 8 shows the mean performance scores (in percentage) of males and females. The present scores obtained by females were higher in all the three tasks than males, indicating a superior performance by females on a rhythm repetition task.

Tasks	Stimuli	(rank correlation co-efficient)
Task 1	Intensity Tokens	0.98
Task 2	Fundamenta1 frequency Tokens	0.97
Task 3	Intensity & fund-mental frequency tokens	0.98
Overal task		0.95

Table 7. r scores for all the three tasks and the overall task.

	Task 1	Task 2	Task 3	Overal scores
Female subjects	39 97	41.64	59.46	47.6
Male subjects	26 65	21.64	35.00	25.3

Table 8. Mean Performance scores (in %) of adult males & females

EXPERIMENT - II : Perception of Rhythm Patterns by Children.

The percent scores obtained by children in the age group , 2.6 to 6.6 years, are depicted in table - 9 and Fig 7. The results indicate that the performance increases from the age of 2.6 - 6.6 years, suggesting a developmental trend for rhythm. It also suggests that the development of speech rhythm starts as early as 2.6 years or much before that & perhaps continues further. A sudden increase in the percent score, can be observed between the age of 4.6 to 5.6 years. Significant differences between the age-groups existed which further supports a developmental trend. This is depicted in fig - 7. Across the sex, females performed better than males, except for a few tokens, task-3 in the age group of 3.6 - 4.6 years, task-2 in the age group of 4.6 - 5.6 years and task-2 in the age range of 5.6 - 6.6 years. This is depicted in table 10.

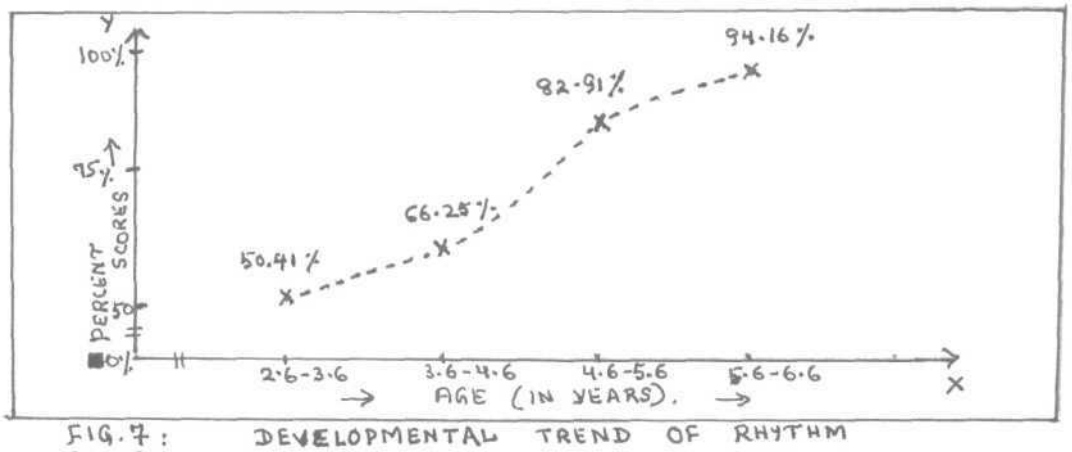

FIG. 7 : DEVELOPMENTAL TREND OF RHYTHM IN CHILDREN.

Age Group of Subjects	Percentage scores obtained for Judge 1			Percentage scores obtained for Judge 2			Percentage scores obtained for Judge 1 & 2			overall mean score of three tasks in I
	Taskl	Task2	Task3	Taskl	Task2	Task3	Taskl	Task2	Task3	
2.6-3.6 Years	45	55	60	37.5	45	60	41.25	50.0	60	50.41
3.6-4.6 Years	47.5	65	75	60	75	75	53.75	70	75	66.25
4.6-5.6 Years	75	82.5	97.5	75	77.5	90	75	80	93.75	82.91
5.6-6.6 Years	93.75	100	100	87.5	92.5	97.5	87.5	96.25	98.75	94.16

Table 9: The overall mean scores of the test in all the four age groups of children.

Age group		Task 1	Task 2	Task 3	Task 4
2.6.-3.6 years	Females	47.5	57.5	62.5	55.8
	Males	35	50	57.5	47.5
3.6-4.6 Years	Females	65	75	72.5	70.8
	Males	42.5	65	77.5	61.5
4.6-5.6 Years	Females	77.5	80	95	84.16
	Males	72.4	80	92.5	81.63
5.6-6.6 Years	Females	90	95	100	95
	Males	85	97.5	97.5	93.3

Table 10 Mean performance scores (in %) of males & females (in children)

Of the three tasks, children performed better on the third task, consisting of Duplex cues for rhythm perception. In the young age group of 2.6 - 3.6 years no significant difference between the performance of

children on various tasks was observed. However, in the age groups of 3.6 - 4.6 and 4.6 - 5.6 years, significant difference between the performance in task 1 and 3 (0.05 level) and tasks 1, 2 and 3 respectively were observed. This is depicted in table 11.

Age groups (in years)	Task 1 versus Task 2	Task 2 versus Task 3	Task 1 versus Task 3
2.6 - 3.6	not significant	not significant	not significant
3.6 - 4.6	not significant	not significant	significant at 0.05
4.6 - 5.6	not significant	significant at 0.01	significant at 0.01
5.6 - 6.6	not significant	not significant	significant at 0.05

Table 11 Significance of the difference between the means of three tasks (child

When the stimuli were considered, it was noticed that the performance scores for all the stimuli increased from the age 2.6 to 6.6. The percent scores decreased from stimuli one (one foot) to stimuli four (four feet) in all the three tasks. (Fig 8)

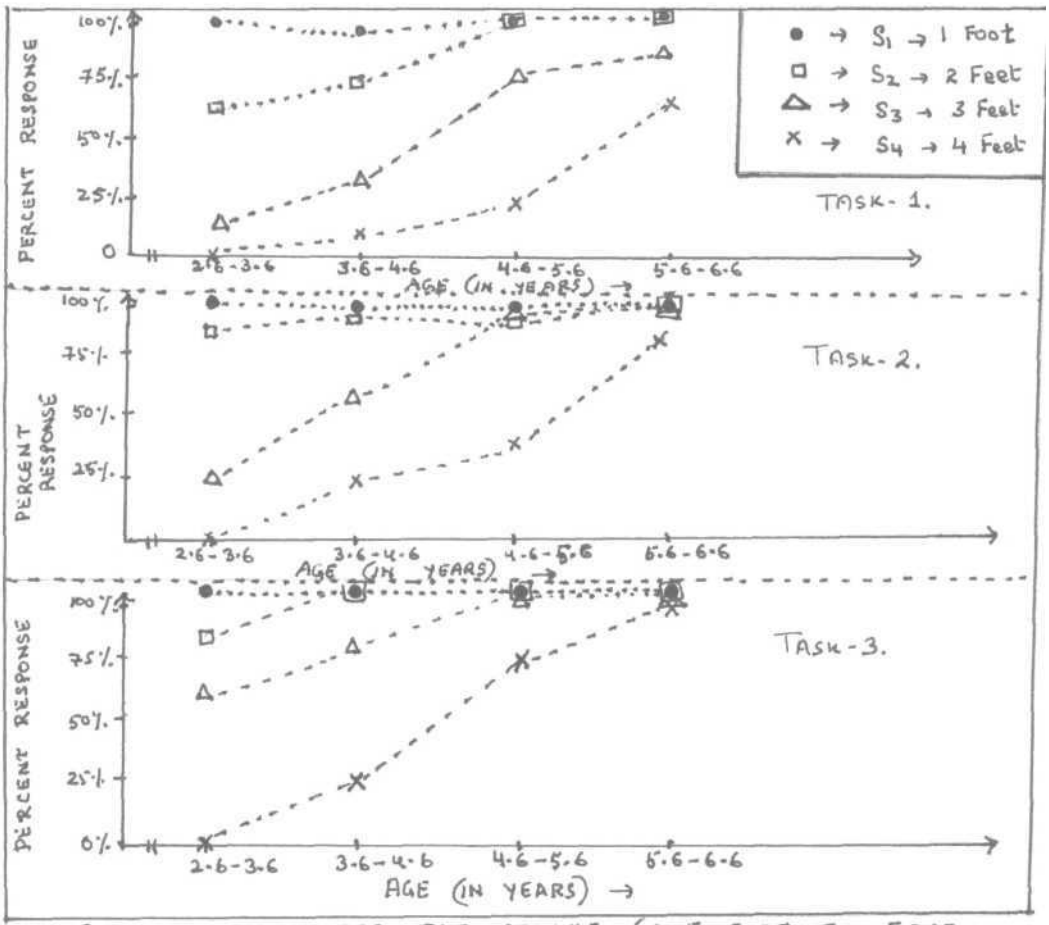

FIG. 8 :- PERCENT SCORES FOR STIMULI (ONE FOOT TO FOUR FEET) IN CHILDREN.

Age groups in children	Task 1	Task 2	Task 3
2.6 - 3.6 Years	0.97	0.96	0.98
3.6 - 4.6 Years	0.97	0.95	0.96
4.6 - 5.6 Years	0.99	0.99	0.99
5.6 - 6.6 Years	0.95	0.99	1

Table 12. Interjudge corrrelation for three tasks

Table 12 represents the interjudge correlation for all the three tasks.

The coefficients of correlation are high (above 0.9 for all) indicating a good interjudge reliability.

To summarize, the results indicate the following:-

1) Adults could imitate stimuli from one foot to four feet and had difficulty in imitating five feet and six feet which indicated the need for deleting five feet and six feet in the second experiment.

2) Stimuli with changes in both intensity and fundamental frequency were better imitated than the other stimuli where only one parameter was altered. This was true, both for adults and children.

3) The performance scores of children increased with age, indicating a developmental trend.

4) Females performed better than males in the synthetic test of rhythm,(both adults and children).

5) The percent scores decreased from one foot to four feet.

DISCUSSION

The results indicate several points of interest. First, it was noticed that normal adults could perceive one, two, three or four feet and found it difficult to perceive five or six feet. This perhaps could be related to the auditory memory and it indicates that five and six feet production could be beyond their memory. Hence, a test of rhythm could encompass only upto four feet.

Second, changes in fundamental frequency and intensity seem to be a better correlate of rhythm than changes in any one of these parameters. Further, changes in frequency produced better perceptional responses than changes in intensity.

The results of this study is in consonance with that of (1955, 58a, b, 1962) and Rigault (1962) Bolinger (1955, 1958a, b, 1962) supports the supremacy of pitch as the perceptual cue which dominates the judgement of stress in English. He reported that a small rise in fundamental frequency could outweigh the intensity differences. Also, Rigault (1962) reported that frequency manipulation gave highly significant judgements in terms of locating stress. Intensity had a much smaller effect and duration had less, still. The results of the present experiment support the notion of Bolinger (1955, 1958a, b, 1962) and Rigauit (1962) that

fundamental frequency changes had better performance than intensity changes.

The result of the present study however, is not in consonance with Fants' notion. Fant in (1960) comments that a 3 dB intensity increase of a syllable leads to the doubling of its amplitude and will be considered equivalent to a doubling of its duration. He also opines that loudness is dependent on duration.

Third, a developmental trend in the perception of rhythm patterns was evident. The ability to percieve rhythm patterns increased steadily from the age of 2.6 years to 6.6 years. The result of this experiment supports the result of Yairi (1981), Koike and Asp (1981). According to Koike and Asp (1981),five year old children did better on the T-TRIP than two year old children. Moreover it was found that mostly younger age group children (2.6 - 3.6 years and 3.6 - 4.6 years) failed to produce four feet pattern accurately. This supports Allen and Hawkins (1980)in that two year old children tend to use far fewer reduced syllables per foot. Their speech sounds are syllable timed rather than stress-timed. Also, in children, it was found that the stimuli with intensity and fundamental frequency changes were precieved better than tokens of intensity or fundamental frequency alone. The performance of

youngest age group in this study, i.e 2.6 - 3.6 years, did not reveal any specific perceptual correlate of rhythm, as no significant difference in the performance of the three tasks, was noticed. Also, no significant differences in the performances of tasks was found in the age group of 2.6 - 3.6 years, thus refuting the findings of Bolinger (1955, 58a, b 1962) and Rigault (1962).

Fourth the results also depicted that females performed better than males in the synthetic test of rhythm for both children and adult groups.

Finally, synthetic stimuli elicited varying responses. While the adults reported that the stimuli were monotonous and boring, the children enjoyed imitating the patterns with claps and enthusiasm. The monotonicity of the stimuli could be perhaps because of unnaturalness of the stimuli. While in normal speech, increments of only fundamental frequency or intensity is rare, in synthetic speech, the surge of subglottic air pressure tends to increase both fundamental frequency and intensity and is directly proportional to the second power of the subglottic air pressure i.e. $I \alpha (Psub)^2$. (Van Der Berg and Ladefoged , 1960). Even, the fundamental frequency rises from 85-115 Hz., when air pressure is doubled. (Wullstein, 1936). These

relationships were not maintained in the synthetic stimuli. Stimulus, depicting the naturalness might be better than the stimuli used, in the present study. However, the purpose of a test would be defeated when natural stimuli is used.

On the basis of the results of the present study, a synthetic test of rhythm is proposed as in fig. 9 where till four feet tokens are included, which relates to Duplex cues of rhythm perception, - change in fundamental frequency and intensity.

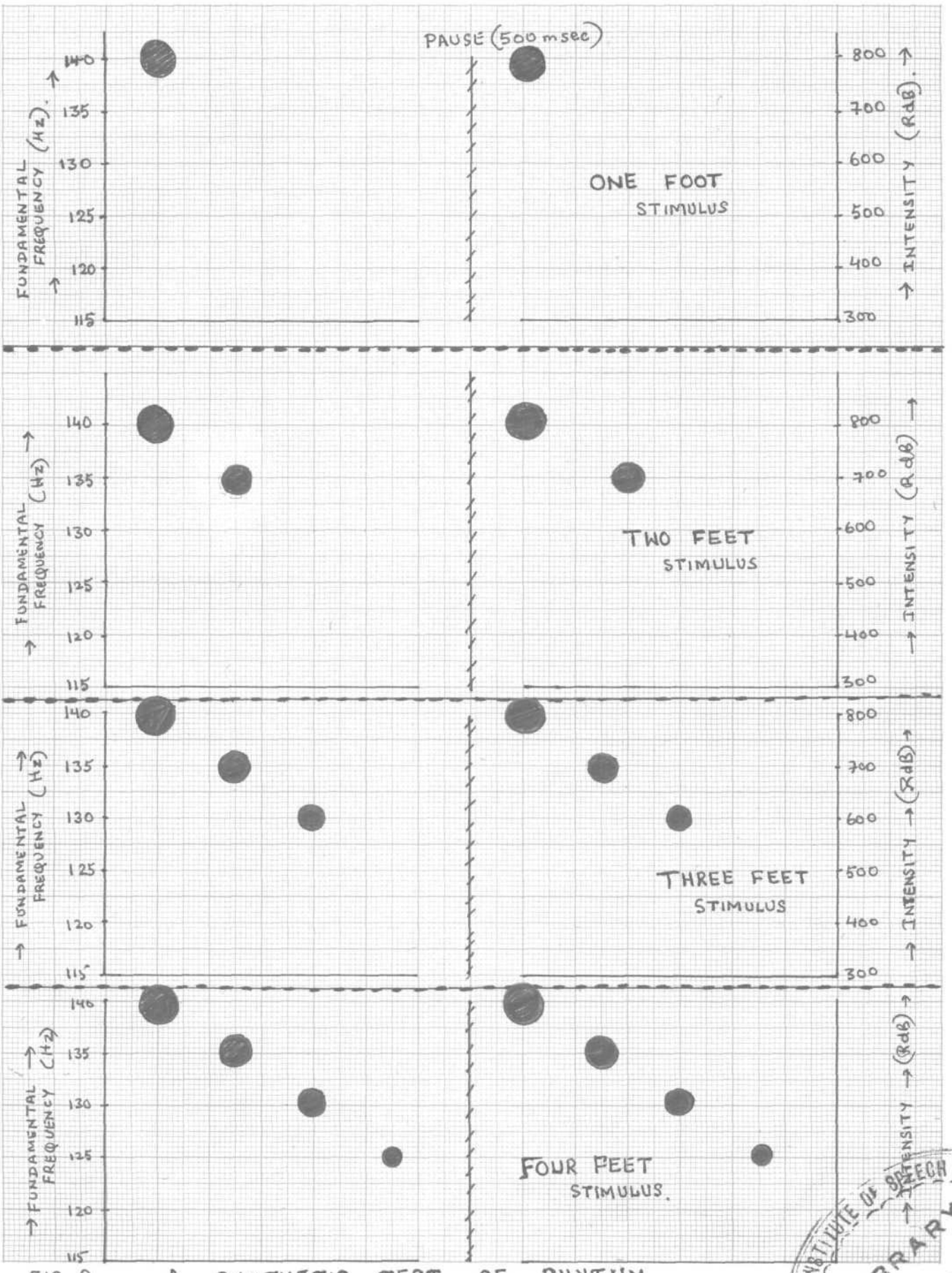

FIG 9. A SYNTHETIC TEST OF RHYTHM

SUMMARY & CONCLUSIONS

Suprasegmentais are properties of speech that have a domain larger than a single element. For being analogous to, superficial decoration, suprasegmentais or prosody consisting of stress, rhythm, intonation & juncture, functions as the foundation or structural support for the organisation of speech communication. Of these, rhythm is intrinsic & critical in both production & perception of speech. Several studies have been conducted in the past to gain a knowledge of the development of speech rhythm in children. However, this topic is not yet understood & there is a pressing need to conduct research in this area, in order to use it clinically. In this context the present study was aimed to highlight the developmental trend of rhythm in childdren & develop a synthetic test of rhythm.

A total of seventeen rhythm patterns were synthesized based on three parameters;— change of intensity, change of fundamental frequency & change of both fundamental frequency & intensity, /ba/ syllable was synthesized for 500 msec, using the acoustic parameters, viz formant frequency, fundamental frequency, formant bandwidth, intensity & duration. The sampling frequency was 8000Hz with a resolution of 10msec. The stimuli were synthesized, based on the

software developed by Voice & Speech Systems, Bangalore. Rhythmic patterns, starting from one foot to six feet were generated, following the method of re-iteration where stressed & unstressed syllables were concatenated. The original /ba/ syllable had a fundamental frequency of 140Hz. Intensity was reduced in 100RdB steps & Fo was reduced in 5Hz steps for the weak syllables.

Two experiments were carried out. Experiment - I dealt with the identification of rhythm patterns by adults. A total of seventeen stimuli were audio-presented to twenty normal adults, who were instructed to imitate the same. Their imitations were recorded and analyzed. A score of '1' was assigned, when the imitation resembled the orginal for rhythm & '0' was assigned when the imitation was inappropriate for rhythm. The percent response was calculated & a test of significance was carried out. The results indicated that the adults could imitate upto four feet & had difficulty in imitating five feet & six feet. Thus, in the second experiment, five feet & six feet were deleted. The second experiment consisited of the perception of rhythm patterns by children. Stimuli til! four feet were audio-presented, one at a time. Forty Kannada speaking normal children in the age range of 2.6 - 6.6 years, were the subjects for the study.

The children were instructed to imitate the patterns for rhythm. These imitations were audio-recorded & judged for imitation. Using the similar scoring system, performances were scored in percent & interjudge correlation was found out.

The results indicated that as the age level increased, performance scores also increased linearly, depicting the developmental trend, for rhythm in children. Regarding the patterns of stimuli, four feet stimuli were relatively difficult than three feet, & three feet relatively difficult then two feet & so on. The task -3, which consisted of duplex cues, i.e. change in both intensity & fundamental frequency, was better than task - 1 & task - 2 in terms of performance. This was true for adults too. The sex difference in the limitation task couldnot be established, since a mixed variety of superiority of sex was found in the tasks, amongst the different age groups.

Considering the results, this test could be used as a clinical diagnostic tools in order to explore the suprasegmentai functioning in patients, having dysprosodia. It may also be used as a therapeutic tool for facilitating rhythmic speech & hence enhancing speech intelligibility in those, who have arhythmia (disorder of rhythm).

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