SPEECH RHYTHM IN MALAYALAM-SPEAKING CHILDREN WITH HEARING IMPAIRMENT

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CERTIFICATE

This is to certify that this dissertation entitled ***" Speech Rhythm in Malayalam Speaking Children with Hearing Impairment "*** is a bonafide work submitted in part fulfilment for degree of Master of Science (Speech-Language Pathology) of the student Registration Number: 14SLP016. This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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This is to certify that this dissertation entitled **"*Speech Rhythm in Malayalam-Speaking Children with Hearing Impairment* "** has been prepared under my supervision and guidance. It is also been certified that this dissertation has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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DECLARATION

This is to certify that this dissertation entitled **"*Speech Rhythm in Malayalam-Speaking Children with Hearing Impairment* "** is the result of my own study under the guidance of Dr. S.R. Savithri, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysore,
May, 2016

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Trust in the lord, with all your heart and lean not on your own understanding, In all your ways acknowledge him, and he will make your paths straight...proverbs 3:5-6.

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INTRODUCTION

Prosody or suprasegmentals refers to features that are superimposed on segmental features (Kent & Kim, 2008). It includes intonation, rhythm, rate, stress, tempo etc. Intonation indicates the pitch movement in a phrase or a sentence; stress to the extra effort, and rate to the number of phonemes/ syllables/words per unit time. Rhythm is the regularity in the timing of successive units of speech. The word rhythm is derived from the Greek word "Rhuthmos" where ″rhu" means flow. According to the Encyclopedia Britannica (1965), rhythm refers to “a pattern of movement, which occurs with more or less temporal regularity or it is a balance swing or in bodily movements, music, verb or phrase”.

In order to characterize different languages, the word rhythm is used to indicate the perceptually distinct alternation between the stressed and the unstressed syllables which is observed as contrastive rhythm. Although a number of acoustic characteristics like fundamental frequency, intensity, duration and the first and the second formant frequencies largely contribute to the differential perception of the contrastive rhythm, most of the work has concentrated on the specific role of timing. For example, it has been observed that in Spanish, the successive syllables are of similar durations, be it stressed or unstressed (“syllable-timed rhythm” or “machinegun rhythm”), but English is believed to highly contrast between the stressed as well as unstressed syllable durations (“stress-timed” or “Morse code rhythm”; Lloyd James, 1940). Trask (1996) defines speech rhythm as “the perceptual pattern produced in speech by the occurrence at regular intervals of prominent elements”. The prominent units which Trask points to can either be accents, stresses or it can be syllables. Pike (1945) and Abercrombie (1965, 1967) classify rhythm in world languages under stress-timed or syllable-timed. In case of stress-timed, syllables recur/repeat at equal intervals of time e.g.: British English and Dutch (Classe, 1939, Pike, 1946, Abercrombie, 1967; Ladefoged, 1975, Smith, 1976), while syllables are considered to have equal duration in a syllable-timed rhythm.

In languages with stress-timed rhythm, speakers appear to have approximately equivalent durations between the stressed syllables which gives way to a different unit of rhythm named as feet. Feet is thought to be comprising of one prominent or stressed syllable which is succeeded by unstressed syllables, of any number, with more or less equal duration; yet each syllable within a foot may differ greatly in terms of duration. In case of Syllable-timed languages, like French or Spanish, the syllables sound to be somewhere around equal duration and show less durational alternation between the stressed and the unstressed syllables. The syllable is considered to be the major unit of rhythm. The two rhythm categories are mutually exclusive, and every language is characterized by either one or the other of these two types of rhythm. In Pike's and Abercrombie's view, "the distinction between stress- and syllable-timing was strictly categorical; languages could not be more or less stress- or syllable-timed". The basis of Abercrombie's (1965) categorical distinction is the physiology of speech production. "All spoken languages were said to have two types of pulses, chest-pulses and stress-pulses. Chest pulses were like puffs of air from lungs, resulting from alternate contractions and relaxations of the breathing muscles. Stress-pulses were less frequent, more powerful contractions of the breathing muscles. Stress pulses were less frequent, more powerful contractions of the breathing muscles which reinforce some of the chest pulses". Abercrombie (1965) suggested that rhythm was a product of the manner of combination of the two pulse-systems. "Two categorically different combinations were possible. In syllable-timing, chest-pulses were in isochronous sequence, but stress-pulses were not. In stress-timing, stress pulses re-enforced chest pulses in isochronous sequence”.

In spite of these classifications, it is difficult to decide the criteria for assigning a language to one of the two rhythm types. Attempts have been made (Dauer, 1983; Ramus, Nespor & Mehler, 1999; Low, Grabe & Nolan, 2000) to expand the dichotomy by adding mora-timed rhythm. The mora-timing was suggested by Bloch (1942), Han (1962), and Ladefoged (1975). An example of mora-timing is Japanese. Traditionally, “morae” refers to sub-units of syllables that consists of a short vowel along with any preceding consonants at the onset. The successive mora units are found to be of approximately equal duration. The mora-timed languages are generally more alike the syllable-timed languages as compared to other stress-timed languages.

Rhythm Class Hypothesis (henceforth: RCH) was proposed by Pike (1945) and Abercrombie (1967) states that “every language belongs to one of the prototypical rhythm classes - syllable timed, stress timed or mora-timed. A rhythm class is defined by assigning equal durations to its basic rhythmic units (i.e. syllables, inter-stress intervals or morae)”. Although accepted among linguists, the RCH has been contradicted by numerous experimental studies. The notion that there is only few and limited number of possible classes along the rhythm dimension is attractive, but has not yet been subjected to extensive test.

Several studies have been conducted to find the parameter with which rhythm could be classified. These include syllable duration (Abercrombie, 1965), inter-stress interval (Roach, 1982), %V, the proportion of time taken by the vocalic segments in the sentence omitting all the word boundaries; ΔV, the standard deviation of the vocalic intervals; ΔC, the standard deviation of the consonantal intervals (; Ramus, Nespor and Mehler,1999) , and Pairwise Variability Index (Low, 1998). The Pairwise Variability Index (PVI) is " an objective metric for the acoustic correlates of speech rhythm, and it computes the patterning or ordering of successive vocalic as well as intervocalic or consonantal intervals denoting the manner in which one linguistic unit varies with respect to its neighbour " (Low, 1998). Grabe & Low (2000) devised "normalized Pairwise Variability Index" (nPVI) for the rhythmic analysis of the vocalic durations. Among the durational measures, PVI is found to be the best predictor of speech rhythm due to the following facts: (a) only PVI takes into account the variability between the successive units, (b) PVI has a normalization component which helps in eliminating the between-speaker differences. The PVI can be obtained as raw PVI or rPVI wherein differences between successive pairs of units are averaged and normalised PVI or nPVI in which each difference is expressed with respect to the proportion of mean of the two units involved. The rPVI was used for the rhythmic analysis of the consonantal or intervocalic intervals and nPVI for vocalic intervals (Low, 1998).

The trend in which children acquire appropriate prosodic structure/pattern is important because it plays a very important role in various aspects of linguistic function, beginning with lexical stress; grammatical structure and emotional affect; thus it is essential for the transmitting the implied meaning and to enhance intelligibility. The Infants and children with normal hearing ability are sensitive to the prosodic aspects of language (supporting studies: motherese: Fernald, 1985; foot structure: Jusczyk, Houston, & Newsome, 1997; Thiessen & Saffran, 2003; phrase boundaries: Hirsch-Pasek, 1987; meter: Jusczyk, 1993; Mehler, 1988). Neurotypical children, by the age of 2–3 years, initiates to master phrasal stresses, boundary cues, and meter in their speech production(e.g., Clark, Gelman, & Lane, 1985; Snow, 1994). Eventually, by the age of 5 years, they are capable of imitating the adult-like patterns (Koike & Asp, 1981). Savithri (2013) studied the development of speech rhythm in typical Kannada speaking children within the age range of 3-12 years and reported that the rhythm class changes from syllabic to mora-timed.

Rhythm is one of the inherent components of fluent speech and provides aesthetic appeal and naturalness to speech. People in different parts of India speak different languages in different dialects which alter the rhythm in each language and its dialect. In India, cross linguistic studies have been carried out in individuals speaking different languages (Savithri, Jayaram, Kedarnath & Goswami, 2006; Savithri, Maharani, Sanjay Goswami & Deepa, 2007). Savithri, Jayaram, Kedarnath & Goswami (2006) investigated on the rhythm of adults speaking Indo-Aryan and Dravidian languages and reported Assamese, Punjabi, Kannada and Telugu to be mora-timed language and Bengali, Malayalam, Tamil and Kashmiri to be syllable-timed languages. Similar differences in speech rhythm have also been found across Non-Indian languages. Abercrombie (1967) found that English, Russian and Arabic are stress-timed languages; French, Telugu and Yoruba are syllable timed language and Japanese as a mora-timed language. Grabe and Low (2002) classified English, Dutch, and German as stress-timed languages, French and Spanish as syllable-timed languages and Japanese as mora-timed language. Since variations in speech rhythm have been observed across languages and dialects, it is not possible to generalize the results of speech rhythm of one language to another.

Rhythm is affected in most of the communication disorders. Clinical population including persons with stuttering, hearing impairment, dysarthria, cerebral palsy etc.

have problems in speech rhythm. One among the most important characteristics in the speech of the deaf or hearing impaired children is lack of prosody. Their speech is monotonous and monoloud with minimal inflections. The relevance of speech rhythm in deaf / hard of hearing was recognized since 1916, when the researcher Alexander Graham Bell stated, "Ordinary people who know nothing of phonetics or elocution have difficulty in understanding slow speech composed of perfect elementary sounds, while they have no difficulty in comprehending a perfect gabble if only the accent and rhythm are natural". Haycock (1933) recommended that only less attention should be given to production of individual phonemes than to the acquisition and the maintenance of prosodic aspects such as quality, stress, accent or intonation. He opined that many children with hearing impairment possessed good quality and rhythmical characteristics before beginning with formal speech training and that the typical analytical approach used was most of the time responsible for hampering such characteristics and even reducing the speech intelligibility".

Children with hearing impairment do not have a control over prosodic aspects. O'Halpin (2001), in his study of prosody in hearing impaired children, cites few factors that would account for prosodic problems: respiratory problems leading to reduced syllables per unit breath (Forner & Hixon, 1977; Osberger & McGarr,1982); inadequate respiratory and laryngeal muscle coordination leading to atypical pausing and lack of variance in the fundamental frequency towards the end of sentences. Moreover, as constructs like stress correlates to numerous physical parameters (e.g. fundamental frequency, intensity, duration), application by children having hearing loss would not always correspond strictly to ambient application, even though there remains a perception of quite apparent precision. O'Halpin warns against rehabilitation that focuses only on individual parameters and not considering the remainders, as this may shift the phonological system of a child in undesirable directions.

Besides, rhythm in speech may get affected in varying degrees in individuals with hearing impairment. Although great consideration has been provided to the core errors in segmental parameters made by the hard of hearing, it has also been realized since long before that suprasegmental errors are the major deficiencies which contribute extensively to the major problem of reduced speech intelligibility in them. The speech of hearing impaired population is characterized noticeably by impairments in timing, voice quality and intonation. Most often, their speech is thought to be slow, along with prolongations of syllables that are stressed and unstressed, inaccurate transitions from one word to another, frequently characterized by the presence of intrusive sounds, and disproportionate and wrongly allotted pauses within the phrase or sentence level. It becomes very important to study speech rhythm in these individuals which might contribute to the overall assessment. Knowledge about speech rhythm is essential in order to rehabilitate the clinical population. In recent years, investigators have initiated to probe into the therapeutic potential of prosodic rhythm in the rehabilitation of speech, language and communication. Further, it is imperative to have knowledge on the development of speech rhythm to have a base for clinical population. The holistic rehabilitation of speech disorder in the clinical population requires the knowledge of normal pattern of prosody including speech rhythm. Studies on speech rhythm in clinical population will provide information on the type of rhythm in them and to diagnose dysrhythmia for a better rehabilitation. Very few studies have been conducted to identify speech rhythm abnormalities in hearing impaired population. Also, data from one language cannot be used in another as the rhythm type may be different. In this context, the present study investigated on the pattern of speech rhythm in Malayalam [Malayalam is a Dravidian language which is spoken in the southern Indian state of Kerala by about 38 million people. It is closely related to Tamil. Malayalam is the official language used in and around the state of Kerala and also in the union territories of Lakshadweep and Puducherry (http://www.wikipedia.com)] speaking children with and without hearing impairment. The specific objective of the present study was to compare the speech rhythm of children with hearing impairment to that of a group of typically developing children.

Chapter II

REVIEW OF LITERATURE

The review deals with the following:

1. Speech Rhythm across languages and Measurement of Rhythm Metrics
2. Acquisition of Speech Rhythm
3. Speech Rhythm in Pathological Conditions
4. Speech Rhythm in Children with Hearing Impairment

1. Speech Rhythm across languages and Measurement of Rhythm Metrics

Speech rhythm refers to temporal patterning of speech events at the level of phonetic segments. Over the years, speech rhythm has been empirically investigated using the notion of isochrony, i.e., classifying the languages as either stress timed or syllable timed (Abercrombie, 1964). Later a new class of languages namely mora timed languages was added to this classification (Hoequist, 1983). As reported by Grabe & Low (2002), rhythmic diversity is the outcome of language specific phonological, phonetic, lexical and syntactic characteristics. Traditionally, languages were grouped into various rhythmic classes based on perception. But with the advancement of several quantification measures such as rhythm metrices, more work is done at the production level. Broadly rhythm metrices can be divided into interval measures (Ramus, Nespor & Mehler, 1999) and PVI or Pairwise variability Index measures (Low, Grabe & Nolan, 2000; Grabe & Low, 2002).Both these measures are acoustic in nature and involve simply segmentation of strings of speech into vocalic and consonantal intervals. However features like syllable complexity, vowel reduction and stress based lengthening have a marked effect on these measures. The interval measures include four rhythm metrics: Delta V (Standard deviation of the vocalic intervals), Delta C (Standard deviation of the consonantal intervals), %V (proportion of the total utterance duration comprising of vocalic intervals), Varco-V (Variable coefficient of vocalic intervals), Varco-C (Variable coefficient of consonantal intervals).

Based on Pairwise Variability Index, Rhythm Class Hypothesis was put forth. The empirical basis of the above mentioned hypothesis has extensively been studied (Beckman, 1992, Laver, 1994). In a language with a simple syllabic structure, such as VC, CCV etc., the differences between the simplest syllable duration and the most complex syllable duration is not so wide. This difference in the durations may account to less than about 330ms . In such conditions, a language is said to have a rhythm which is a fast syllable-timed rhythm. Now, in cases when the syllabic structure is again simpler, then there is only a negligible durational difference between syllables and it is termed as a mora-timed language. However when a particular language has a complicated syllable structure, i.e., CCCVCC (strength), the durational difference or the gap between two syllables could be very wide. Under such circumstances, one should be using slow stress-timed rhythm.

The development of the concept of measurement of rhythm or rhythm metric began with the idea of *isochrony* wherein “the successive syllables are said to be of approximately equal length or the interval between two stresses is said to be of equal length”. The initial effort to test the Rhythm Class Hypothesis has been taken by Abercrombie (1967). He recorded picture descriptions and spontaneous speech of one speaker each in languages of French, Telugu, Yoruba, English, Russian, and Arabic and used (1) Intensity traces, and (2) Average syllable duration. English, Russian and Arabic were earlier classified as stress-timed languages. Results indicated almost equal SD across languages (French - 75.5, Telugu - 86, Yoruba - 81, English - 86, Russian - 77, Arabic – 76) and did not support the rhythm class hypothesis. But, based on his study, Abercrombie made two claims - (a) stress-timed rhythm has variation in syllable length and syllable-timed rhythm has equal syllable durations, and (b) Inter-stress interval (ISI) are unevenly spaced in syllable-timed languages.

Roach (1982) investigated these two claims and compared those languages which are categorised as syllable-timed and stress-timed. Results indicated greater inter-stress interval (ISI) variability in syllable-timed languages as compared to stress-timed languages and revealed a greater range of percent deviations in ISI in stress-timed languages compared to syllable-timed languages which did not support the claims of Abercrombie.

Ramus, Nespor, and Mehler (1999) used a different measure. They analyzed 5 sentences spoken by 4 speakers of 8 languages (English, Italian, Polish, French, Catalan, Dutch, Spanish, and Japanese) and measured (a) vocalic intervals or vocalic durations, % V, (b) SD of vocalic intervals, Δ V, and (c) SD of consonant intervals, Δ C. They excluded word boundaries during measurements. Results indicated that % V and Δ C metrices were the best acoustic predictors of rhythm classes. In English % V was smaller than compared to French, as it do not usually have vowel reduction. Δ C was greater in English compared to other languages. Thus English had more complex syllable options. Based on % V and Δ C English, Dutch, and Polish were classified into stress-timed languages whereas French, Italian, Catalan, Spanish within syllable-timed languages, and Japanese into a mora-timed language. The following figure 1 shows the classification of rhythm types by Ramus (2002)

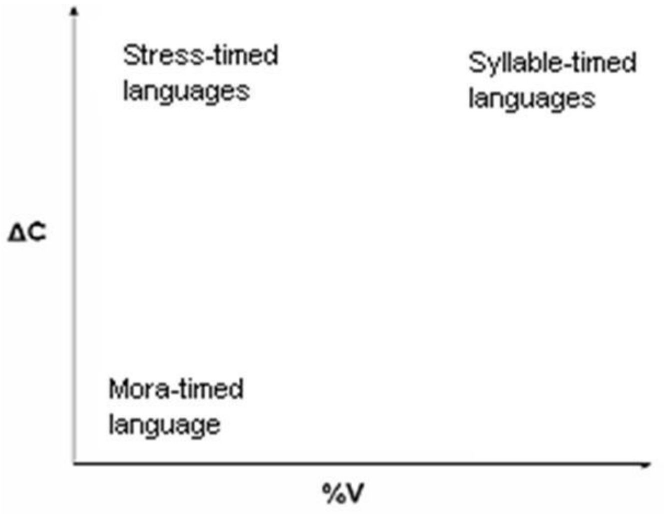

Figure 1: Classification of rhythm based on %V and ΔC.

The Pair-wise Variability Index (PVI**)** popularised by Low, Grabe and Nolan (2000) made use of a similar kind of comparison. The PVI can be computed as "raw" (rPVI), wherein "the differences between the successive pairs of units are averaged". Raw Pairwise Variability Index (rPVI) is for the rhythmic analysis of consonantal or intervocalic durations. Low, Grabe and Nolan (2000) developed "normalized Pairwise Variability Index" (nPVI) for rhythmic analysis of the vocalic durations. Normalisation denotes "expressing each difference or variation as a proportion of the average of the two units involved". In an independent study by Ramus (2002), he evaluated 8 languages for the duration and variability of both the vocalic and intervocalic intervals. The whole rationale or idea behind considering intervocalic intervals are that the stress timed languages tends to allow syllables that are more complex and hence, much longer as well as variable consonantal sequences than compared to syllable timed languages. The duration of the vowels and the duration between two successive vowels were measured. Then PVI was computed using the following formulae:

$$PVI = \left[\sum_{k=1}^{m-1} \left| \frac{d_k - d_{k+1}}{(d_k + d_{k+1})/2} \right| / (m-1) \right],$$

Where, m refers to the number of vocalic (v) or consonantal (c) intervals and dk indicates the duration of the k^{th} interval.

This means that the difference in an acoustic property between the members of successive pairs of intervals is calculated, then normalised by taking each difference as a proportion of the mean value within the pair, and averaged across the total number of interval pairs in the speech analysed. Using the PVI, Low et. al., found that Singapore English was more of syllable-timed rhythm than British English. Table 1 gives a summary of the basic characteristics of the language classes with respect to relative values of both the vocalic nPVI and intervocalic rPVI.

Language class	Languages	Intervocalic interval(IV)	Vocalic interval (V)
Stress-timed	English, German	High	High
Syllable-timed	French, Spanish	High	Low
Mora-timed	Japanese	Low	Low

Table 1:
Summary of basic characteristics of each language class regarding relative values of vocalic nPVI and intervocalic rPVI.

Low, Nolan, and Grabe (2000) did a comparative study using the nPVI and the standard deviation measures Δ V and Δ C. They came to a conclusion that a PVI might be a better indicator of rhythmicity than the other measures, Δ V or Δ C. In a less strictly controlled data, the author Low and his colleagues argued that the standard deviation will reflect spurious variability brought about by changes in the speaking rate within sentences, across sentences and across speakers. For instance, consider a language with three consecutive long vowels and another language wherein long and short vowels alternately occur. Both will yield similar standard deviations, even though the patterns of vowel durations varies greatly among the two.

Grabe & Low (2002) calculated PVIs in languages traditionally classified as stress-timed, syllable-timed, mora-timed and unclassified languages using passages spoken in 18 languages. Based on PVIs, English, Dutch, and German were classified as stress-timed languages; French along with Spanish were classified as syllable-timed languages and Japanese as mora-timed language. Remaining languages were unclassified.

The PVI is the measure of the absolute difference of the vowel duration of two adjacent syllables when divided by the average vowel duration of the same two adjacent syllables. Suppose a sentence has m syllables, it yields m-1 PVIs. These PVIs represent the variability of vowel duration, with lower PVIs representing a more syllable-timed language. PVIs do not represent an index of the absolute rhythm of any language; instead they allow the comparison of the rhythms of two or more languages or varieties. PVI has been adopted as an apparently transparent accurate method of comparatively classification of speech rhythms.

Savithri, Jayaram, Kedarnath & Goswami (2006) investigated rhythm in two etymologically unrelated languages – an Indo Aryan (Hindi) as well as a Dravidian (Kannada). Twenty normal adult speakers (10 males and 10 females) of each language within 18-25 years of age participated in the study. A1000 words passage was used in Kannada and Hindi. Reading and spontaneous speech were recorded and analyzed for PVIs. Results revealed Kannada to be a mora-timed language and Hindi to be a syllable-timed language.

Savithri, Maharani, Sanjay and Deepa (2007) examined rhythm in twelve Indian languages – Assamese, Bengali, Gujarathi, Kashmiri, Marathi, Oriya, Punjabi, Rajasthani, Kodava, Malayalam, Tamil and Telugu. Twenty normal adult speakers (10 males and 10 females) of each language within 18-25 years of age participated in the study. A hundred word passage was prepared in all those languages (except for Kashmiri and Kodava which do not have script) for reading task. Vocalic and consonantal/ intervocalic intervals were measured in readings of adults in each of these languages. Results showed Assamese, Punjabi and Telugu to be mora-timed language and Bengali, Malayalam, Tamil and Kashmiri to be syllable-timed languages.

2. Acquisition of Speech Rhythm

Measuring and classifying rhythm in speech may be somewhat elusive from an objective or instrumental perspective, but the classification of rhythm classes perceptually seems to be there even in the very earliest developmental stages of language. Hrushovsky (1960), Moskowitz (1970), Waterson (1970), Smith (1973) and Ingram (1974) proposes that speech rhythm in young children will mostly be syllable timed, as their early polysyllabic utterances are majorly composed of reduplicated forms which are short sequences of monosyllables which are phonologically similar. The acquisition of speech rhythm in monolingual versus bilingual children has always been a topic of growing interest in view of linguistic production (Demuth, 1996; Grabe, Post, &Watson, 1999; Lleo & Demuth, 1999; Curtin, 2000; Gut, 2002; Kehoe & Stoel-Gammon, 2001).The researchers Grabe, Post, and Watson (1999) probed into the production of rhythm in speech by monolingual children speaking British-English and French at the age of four. Using the nPVI for vocalic durations, the investigators obtained a highly significant effect of language. On comparison, the children speaking English had greater variability index scores when compared to the children speaking French. Also, a significant interaction was obtained between the languages and the age as children speaking French had durational properties that were more equivalent to the mothers' durational patterns, but English speaking children had more of an even timing pattern as compared to the mothers'. When the young children and adults were compared in the study, the young children had more even timing than the adult group, irrespective of their language, indicating that a less regular timing pattern may be more marked linguistically on comparison with a more regular timing pattern. They regard a less equally timed rhythm pattern linguistically more marked on the basis of an acquisition point of view as it apparently seems to be the default, basic and more universal setting for speech rhythm acquisition in its early stages (Grabe, Post, & Watson, 1999; Hochberg, 1988). Thus, it is generally expected that the development of speech rhythm proceeds from an equal timing pattern to a more target-appropriate pattern in case the language that needs to be acquired is intrinsically more variable in timing.

Nazzi, Jusczyk, and Johnson (2000) observed 5-months-old monolingual American-English and found that infants were able to differentiate between their own language and any other dialect based only on prosodic cues. Infants could even identify the versions of English as different from another language which is of the same class of rhythm or one language from another category of rhythm class (for example, (a) British English from Dutch, and (b) British English from Japanese). Additionally, distinguishing between two different languages that were non-familiar, belonging to different rhythm classes was demonstrated (e.g; distinguishing Italian vs. Japanese).However, infants were not able to distinguish between languages which belonged to similar rhythm classes (For e.g.; infants learning English couldn't differentiate between Italian and Spanish, and between Dutch and German).

Whitworth (2002) analysed the rhythm acquisition in six bilingual children speaking both German and English languages in the United Kingdom within the age range of 5.0 to 13.2 years. Both German and English languages are classified within stress-timed languages. The study provided details on the separation of languages based on rhythm that are categorically similar in speech rhythm. The author stated that "bilingual German- and English-speaking children were even aware of the fine-grained variability that occurred in the rhythm of their target languages and they could produce patterns that closely resembled the adult targets, although they were not identical to the adult target". The results also specified that the younger group had lesser vocalic variability and more intervocalic variability in comparison to the older group. Whitworth finally concluded by saying that even minute and fine-grained phonetic information on speech rhythm was differentiated by bilingual children, even when speech rhythm wasn't fully acquired in either of the language-speaking bilinguals until the age of 11 years.

Bunta and Ingram (2007) investigated acquisition of speech rhythm by bilingual Spanish-speaking children and English-speaking children, making use of the Pairwise Variability Index (PVI) measures given by Grabe and his colleagues. Results showed that the younger bilingual children exhibited distinct patterns of rhythm in their target languages, and that they differed from their English-speaking peers who are monolingual. Older bilingual group could differentiate and distinguish between the speech rhythm with respect to language, and the differences of the older bilingual group compared to the monolingual group speaking English were also noticed. Both the Younger as well as the older bilingual groups varied only on vocalic PVI, and not on the intervocalic PVI, supporting age differences partially.

Savithri, Sreedevi & Kavya (2009) looked into the parameter of speech rhythm in normal Kannada speaking children within the age range of 8 – 9 years. The raw PVI for the children was ranging from 44.97 to 78.17 along with an average value of 65.90 and the normalized PVI values were ranging from 80.10 to 122.75 with an average value of 96.06. The results showed a high nPVI and a low rPVI value which concluded that the rhythm was unclassified or did not qualify to be categorised under any prototypical rhythmic classes (such as stress-timed, syllable-timed and mora-timed). The study also enlightened on the syllabic structure that is used by the young children which were simpler initially and became complex during the developmental stages of acquisition of rhythmic patterns. It also indicated that the rhythmic pattern found in both boys and girls were similar although girls showed a tendency to acquire the adult pattern earlier.

Savithri, Sreedevi, Jayakumar, Kavya (2010) studied speech rhythm in normal

Kannada- speaking children making use of the Pairwise Variability Index. The participants comprised of three groups (4-5 years, 8-9 years, and 11-12 years). A five minute narrated speech sample was recorded from each of them and analysed. Results revealed that children produce durational differences by 4-5 years, but their rhythm productions were characteristically varying, stabilising to an adult-like pattern by around the age of 11-12 years.

Savithri, Sreedevi, Deepa and Aparna (2011) explored the rhythm in 3-4 year old typically developing Kannada speaking children. The results indicated mean vocalic PVI to be lower than mean intervocalic PVI. Therefore, rhythm was classified as syllable-timed.

Savithri, Sreedevi, Deepa, Aparna, and Shylaja (2012) studied rhythm in 4-5 year old typically developing Kannada speaking children using pair-wise variability index of durations. Results showed no significant difference between boys and girls. They found high standard deviation and no significant difference between both the PVIs. The rhythm in this age group was classified as mora-timed.

3. Speech Rhythm in Pathological Conditions

Rhythm abnormalities are seen in a variety of communication disorders. Few of them include hearing impairment, autism, stuttering, dysarthria, aphasia etc. Hargrove (1997) reviews the various types of prosodic indicators presented by children with autism, hard of hearing, developmental delay, and Specific Language Impairment. Hargrove quotes "incomplete control of phrasal stress" as the major prosodic impairment in these children. He proposed that children having Specific Language Impairment will exhibit variabilities in production of the unstressed syllables. He also said that they seem to be more likely to omit syllables which are unfooted as compared to those belonging to a strong-weak feet.

Rhythm irregularities are common in dysarthria. Motor disorders hinders the flow of syllable stream and impacts on the perceived speech rhythm at the level of articulatory implementation rather than from the phonological constraints. Darley, Aronson, and Brown (DAB, 1969) used terms such as “exaggerated and equal stress”, “reduced stress”, “short rushes of speech”, and “prolonged segments”, along with others, to denote the perception of rhythmic disturbance. Analysis of speech rate in patients with Parkinson’s Disease showed an impaired rhythm and improper timing organization, i.e.; an accelerated articulatory rate while speaking, and also reduced number of pauses (according to Skodda and Schlegel, 2008; Skodda, Flasskamp and Schlegel 2010). Dahamani, Selouani, O’shaughnessy, Chetouani and Doghmane (2012) reported that PVI results were more scattered in dysarthric group compared to controls suggesting more variability in their speech rhythm.

Dankovicova, Gurd, Marshall, Macmohan, Stuart-Smith, Colema and Slater (2001) showed hardly any prosodic disturbance in a patient with RHD. He also studied the speech of an English speaker with Foreign Accent Syndrome along with ataxic dysarthria and found it to be more syllable-timed compared to the normal controls.

Amulya and Swapna (2013) studied speech rhythm in individuals with Parkinson’s Disease. Twelve individuals (6 males and 6 females) with Idiopathic PD and 12 control matched for age and gender in the age range of 60-85 years were included in the study. A reading task was used to assess the speech rhythm. The nPVI values were higher for the clinical group across early, mid and late stages indicating more clustering and prolonged phonemes in production.

Stuttering is one of the developmental condition which impairs the fluency of speech. Symptoms of stuttering include repetition of part words or whole words, prolongations of sounds, leading to disruptions within the normal flow of speech. Several studies have investigated speech and non-speech timing deficits in stuttering (Cooper & Allen, 1977; Kleinow & Smith, 2000; Olnder, Smith & Zelaznik, 2010). Santosh & Sahana (2013) compared rhythm in individuals with and without stuttering. Fifteen adult male persons with stuttering and fifteen age and gender matched controls participated in the study. Subjects were instructed to read five prepared set of sentences and rhythm metrices were obtained. Results revealed higher mean values in Adults with stuttering than controls for nPVI, %V, delta V and Varco C indicating that speech rhythm was more variable in stutterers.

Aphasia is one of the very common and devastating aftereffect of stroke or injuries to brain that results in cognitive communicative dysfunction. When there is impaired speech production, such patients are typically classified within the category of "non-fluent aphasia". They have halting speech with lot of pauses and arrhythmias. Individuals having Broca's aphasia, damage to the corpus callosum, and also Traumatic Brain Injury has been identified to have impairment in expressive prosody (Danly & Shapiro, 1982; Klouda, Robin, Graff-Radford, & Cooper, 1988; Theodoros, Murdoch, & Chenery, 1994; Wang, Kent, Duffy, & Thomas, 2005).

4. Speech Rhythm in Children with Hearing Impairment

One of the fundamental factors for the perception and production of speech is the proper functioning of the auditory system. During the period of language development, the linguistic input that children receives from the speech of others, subserves as the target to achieve. Additionally, children's auditory feedback helps them to steadily correct the errors in their speech, till it equates with their target (Borden, 1979; Northern and Downs, 1991; Stoel- Gammon and Kehoe, 1994; Wallace, Menn and Yoshinaga-Itano, 2000; Kuel, 2000; Obenchain, Menn and Yoshanaga-Itano, 2000). Auditory deprivation following hearing deprivation in the initial stages of life impairs the different aspects of language development, including the patterns of speech production (Lee and Canter, 1971; Pressnell, 1973; McGarr and Osberger, 1978; Oller, Jensen and Lafayette, 1978; Quigley and King, 1982; Wood, 1984; Levitt, McGarr and Geffner, 1987; Madison and Wong, 1992; Tobin, 1997). The speech production of hard of hearing children is characterized by multiple segmental and suprasegmental errors. The major segmental errors include sound omissions, distortions, and substitutions (Hudgins and Numbers, 1942; Markides, 1970; Smith, 1975; Monsen, 1976; Stevens, Nickerson and Rollins, 1978; Geffner, 1980; Osberger and McGarr, 1982; Tobin, 1997). Suprasegmental errors usually are seen in the stress and intonation pattern, which affects the prosody as well as the rate of the speech (Boothroyd, Nickerson and Stevens, 1974; Osberger, 1978; Parkhurst and Levitt, 1978; Rosenhouse, 1986; Frank, Bergman and Tobin, 1987). It has been identified that prosodic skills at the word and the phrasal level in children with hearing impairment are poorer than the normally hearing children in terms of both reception and production.

(Carter, 2002; Lenden & Filipsen, 2007; Peng, 2007, Lyxell, 2009).

Hudgins and Numbers (1942) claimed that the rhythm and articulation of consonants are more relevant in contributing to the overall intelligibility of hearing impaired speech than the vowel articulation. Hence there are better chances of being understood if the sentence is produced in an appropriate rhythm. The proper timing or rhythm of speech is affected by factors such as the overall rate of speech, duration of phonemes, pauses, and syllable grouping. Voelker (1935, 1938) attempted to quantify the durational characteristics of speech of hard of hearing children. In Volker's previous study, he pointed that the hard of hearing had a median phonation time of which was nearly 2.5 times relative to the normally hearing subjects. The median rate of speech of the normally hearing children was four times as compared to that of the deaf children. In other words, hard of hearing children tends to prolong vocalizations and even pauses longer between words than normal-hearing children; the overall effect was that on an average deaf children took almost four times as long as the normal child to complete a sentence. Voelker (1938), in his later study, made his hard of hearing participants to practice saying the sentences. A hard of hearing child's median rate of speech was about 70 words per minute, when compared to a normal-hearing child who had a median rate of 164 words per minute. This clarifies that, even with practice, most of the deaf children took about twice longer than the hearing subjects to finish an utterance. Deaf speakers have reduced fundamental frequency (F0) variation relative to normal-hearing speakers. Voelker (1935) found that compared to normal children, deaf children used hardly a little more than half the frequency range used by the normal children. Green (1956) also proposed that deaf children had a very restricted fundamental frequency range, as compared to those values obtained by other researchers who studied normal participants who received varying inputs of speech training.

The phonemic duration is thought to be distorted in the deaf speech. Generally, there is a tendency among the deaf children towards lengthening or prolongation of vowels and consonants (Angelocci, 1962; Calvert. 1962; John and Howarth, 1956; Boone, 1966; Levitt, Stromberg, Smith, and Gold, 1974; Parkhurst and Levitt, 1978). Angelocci claimed that the deaf subjects had taken over 4 to 5 times longer durations to say fricatives when compared to that taken by his normally hearing subjects. The closure durations of stops were also largely prolonged. According to Hood (1966)) training children on duration of phonemes would improve intelligibility greatly if articulation is good. Monsen (1976) did a study on 12 hearing impaired and 6 normally hearing adolescents, and asked them to read fifty six CV(C) syllables containing both the vowels /i/ or **/I/.** The author reported that the participants who were deaf, seemed to develop durational classes for both the vowels, which are mutually exclusive, in such a way that the duration of one of the vowel could not be approximated to that of the other even in different consonantal contexts. For the normally hearing subjects, the vowel duration of /i/ was most of the time longer than /I/ in a specific consonant context, however absolute durations of both the vowels tend to overlap when the contextual consonants varied. Therefore, even though the vowels that were produced by the hearing impaired subjects were different with respect to duration, they still had less intelligibility as the listener couldn't depend on the normal strategies for decoding in order to understand what was heard. The researchers

Sussman & Hernandez (1979) carried out the spectrographic analyses of different suprasegmental domains of the speech of ten adolescents with hearing-impairment. Along with the other findings, they identified that the vowel produced before the voiced stops were longer than those produced as only very small voicing was present as compared to normal speakers.

Another manifestation of the prolonged phonemic duration relates to the differentiation between the stressed and the unstressed syllables. Nickerson (1974) calculated the duration of syllables in four short utterances using a reading task in twenty five deaf and normally hearing children respectively. They computed the ratio of the duration of stressed syllables to the ratio of unstressed syllables near it. The results indicated that the deaf children were not able to produce stressed versus unstressed syllable durational differences that were greater when produced by the normal-hearing children. Both the groups, the deaf and the normally hearing children tried to prolong the final positioned syllables of phrase or sentence. Additionally, the deaf participants prolonged even the unstressed syllables. Authors like Boothroyd, Nickerson, & Stevens (1974) stated that the unstressed syllables usually take twice as long time for the deaf than for the normally hearing group. Angelocci (1962) proposed that the unstressed vowel durations when produced by the deaf speakers were around 4 to 5 times as long as the median time taken to produce them by the normal- hearing speakers. This lack of distinction between the stressed and the unstressed syllable length contribute to the listener's correct perception of inappropriate stress in the speech of the deaf as stated by Hudgins (1946) and Levitt (197 1). McGarr (1976) found that when the subjects in her study(125 deaf subjects) were asked to read the test sentences prepared to analyse their ability to produce appropriate stress, pause, and rising intonation, one out of the four subjects gave equal stress to all the words that were read, which gave an impression reading in a staccato fashion. Thus the duration is not just prolonged for the unstressed syllables, but also for the stressed syllables. The investigators, John & Howarth (1965) reported that the durations of simple monosyllabic words when said by the deaf speakers were approximately twice as that for the same words uttered by the normal-hearing children. Observer (1978) collected the recorded speech samples of hearing impaired children and then manipulated it to alter the deviant patterns of timing. Pauses were initially eliminated, and both the absolute and the relative durations of syllables were altered in an attempt to produce more intelligible speech.

Savithri, Johnsirani and Ruchi (2008) researched on the speech rhythm in children with and without hearing impairment within the age range of 5-10 years. The mean values of intervocalic PVI and vocalic PVI for the normal group were 15.70 and 62.49, whereas that for the hearing-impaired group was 20.54 and 67.14, respectively. The results obtained had a high vocalic PVI and a low intervocalic PVI and hence the rhythmic pattern was unclassified as it did not fit into any of the prototypical rhythmic categories (stress-timed, syllable-timed, and mora-timed). The results also revealed that children tend to use a simpler syllabic structure in the early acquisition stage of rhythmic patterns.

The review indicates that speech rhythm has not been much investigated in persons with hearing impairment and that it is essential to know about the rhythm used by persons with hearing impairment in order to train them on proper rhythm. In this context, the present study investigated the type of speech rhythm in Malayalam speaking children with and without hearing impairment. The specific objective of the study was to compare the speech rhythm of children with hearing impairment with a group of typically developing children.

Chapter III

METHOD

Participants: Two groups of subjects participated in the study. Group I included five native children (1 girl and 4 boys) with hearing impairment in the language age of 3-4 years. The inclusion criteria were as follows:

(a) Malayalam as the mother tongue,

(b) Bilateral severe sensory-neural hearing impairment and using hearing aid before 3 years of age,

(c) Language age of 3-4 years on Extended REELS,

(d) Attended regular pre-school at All India Institute of Speech and Hearing, Mysore, and

(e) No other structural and/or functional deficits.

Group II included five typically developing Malayalam speaking children (3 girls and 2 boys) in the age range of 3-4 years. All the participants were screened with Extended Receptive Expressive Emergent Language Scale for their language ages and confirmed by administering Malayalam Language Test (MLT). Table 2 shows the demographic details of both the groups.

Group I				
Participant	Age(in years)	Language age	Gender	Status of hearing
1	5.6	3.6- 4	Female	Bilateral profound hearing loss
2	4.6	3- 3.6	Male	Bilateral severe hearing loss
3	5	3.6 - 4	Male	Bilateral severe-profound hearing loss
4	4.6	3- 3.6	Male	Bilateral profound hearing loss
5	4.2	3 – 3.6	Male	Bilateral profound hearing loss
Group II				
1	3.5	3.6- 4	Female	Within normal limits
2	3.2	3-3.6	Male	Within normal limits
3	3.7	3.6- 4	Male	Within normal limits
4	3.6	3.6- 4	Female	Within normal limits
5	4	3.6- 4	Female	Within normal limits

Table 2: Demographic details of children in both groups.

Stimuli: A five-minute speech sample with a minimum of 100 words was elicited from each of the subject using simple pictures in the fluency test given by Nagapoornima (1990) for children of the age of 3-4 years.

Procedure: Children were tested individually in noise free environment. They were seated comfortably and asked to carefully see the pictures presented and to describe them. Prompts were used initially when the child failed to respond by himself or herself. Speech samples were elicited and audio-recorded with the use of a digital voice recorder (Olympus-WS-100) or Computerized Speech Lab (CSL) at the sampling frequency of 44100 Hz.

Acoustic Analyses: The collected speech samples of the subjects were transferred to the computer system and later analyzed using the PRAAT software developed by Boersma & Weenik (2015) and displayed as a waveform. The pauses in the sample were then eliminated with the help of the same software in order to obtain an appropriate measurement of the vocalic and non-vocalic segments. The Vocalic (V) interval and Intervocalic (IV) interval were highlighted with the cursor and the durations were measured. The vocalic interval refers to the duration of either the vowel, semivowel, or diphthong which is taken as the duration between the onset of voicing and the offset of voicing for the same. The intervocalic interval (duration between two vocalic segments) refers to the duration from the offset of the n^{th} vocalic segment to the onset of (n+1) vocalic segment. Figure 2 shows marking of vocalic and intervocalic intervals.

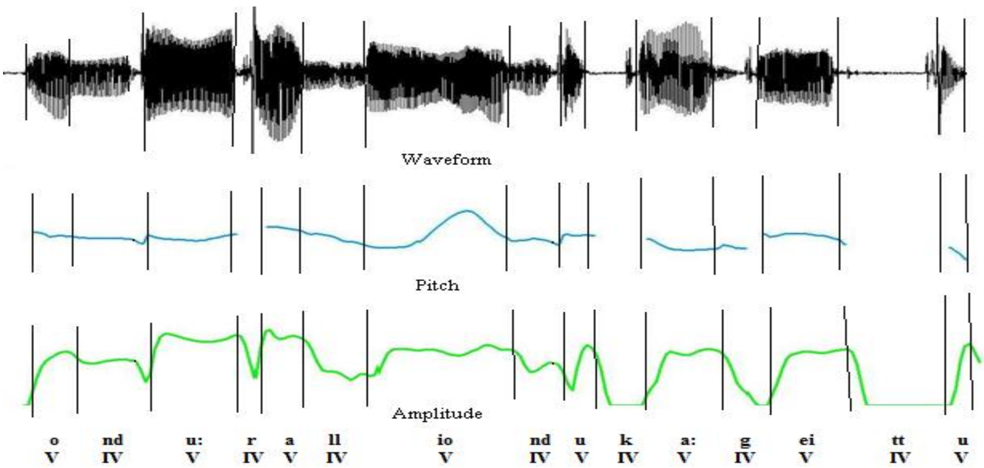

Figure 2: Marking of vocalic and intervocalic intervals on waveform, F0 and intensity curves.

The rules that governed the segmentation of sounds were on the basis of former studies on acoustic analysis (e.g.; Peterson & Lehiste, 1962). The boundary between vocalic and intervocalic intervals was indicated by a significant drop in the amplitude and a break in the second formant structure. The spectrographic cues associated with the manner of production made it easier to identify the consonantal boundaries. Besides this standard criterion, a few other factors were taken into consideration in order to get consistency in the measurements. Approximants were taken as a part of the vocalic interval as it is difficult to reliably determine their boundaries (White &

Mattys, 2007). Pre-vocalic glides were taken as part of consonantal duration whereas the post-vocalic glides as part of vocalic durations (Ramus et. al., 1999). Aspiration following release of stops was considered in consonantal durations (White & Mattys, 2007). Even though a significant lengthening was noticed in the final position of phrases, it was excluded from the analysis. Glottal /h/ was taken as a part of vocalic durations as it was difficult to segment it and for uniform analysis.

The durational difference between successive segments, i.e, the vocalic and intervocalic segments was computed and averaged in order to get the nPVI for both vocalic and intervocalic intervals. Pairwise Variability Index, given by Grabe and Low (2002) was used as a metric of rhythm. PVI was derived using the following formulae in Microsoft office excel:

$$PVI = \left[\sum_{k=1}^{m-1} \left| \frac{d_k - d_{k+1}}{(d_k + d_{k+1})/2} \right| / (m-1) \right],$$

Where, m is the number of vocalic (v) or intervocalic (c) intervals and dk is the duration of the k^{th} interval.

Statistical Analyses: Statistical analysis of the data was carried out in the commercially available SPSS (version 18) software. Both descriptive an inferential statistics were carried out. Under descriptive statistics, median and standard deviation were measured and under inferential statistics Mann-Whitney U test (across group comparison) was employed.

Chapter IV

RESULTS

Results will be described under the following headings:

(1) Results of descriptive statistics

(2) Individual data

(3) Type of speech rhythm in Malayalam speaking children with and without hearing impairment

(1) Results of descriptive statistics

The mean VPVI for group I and II were 0.223 and 0.184 and that for IVPVI were 0.293, and 0.286, respectively; The median for VPVI for group I and II were 0.213 and 0.199 and the median for IVPVI for group I and II were 0.289 and 0.286, respectively. Results of Mann- Whitney test showed a significant difference between groups on VPVI values ($p<0.05$). The median VPVI was higher in group I compared to group II. It was interesting to note that the standard deviations for both PVIs was higher in group II compared to group I. Table 3 shows the mean, median, SD of VPVI in both groups and the Z value. Figure 3 shows the mean values of PVIs in both the groups A comparison of VPVI and IPVI across Group I and Group II is given in Figure 4.

	Group I			Group II			
	Mean	Median	SD	Mean	Median	SD	/z/ value
VPVI	0.223	0.213	0.019	0.184	0.199	0.027	2.611*
IVPVI	0.293	0.289	0.015	0.28	0.286	0.081	0.731

*p < 0.05

Table 3: Mean, Median, SD of PVIs in both groups and the Z value

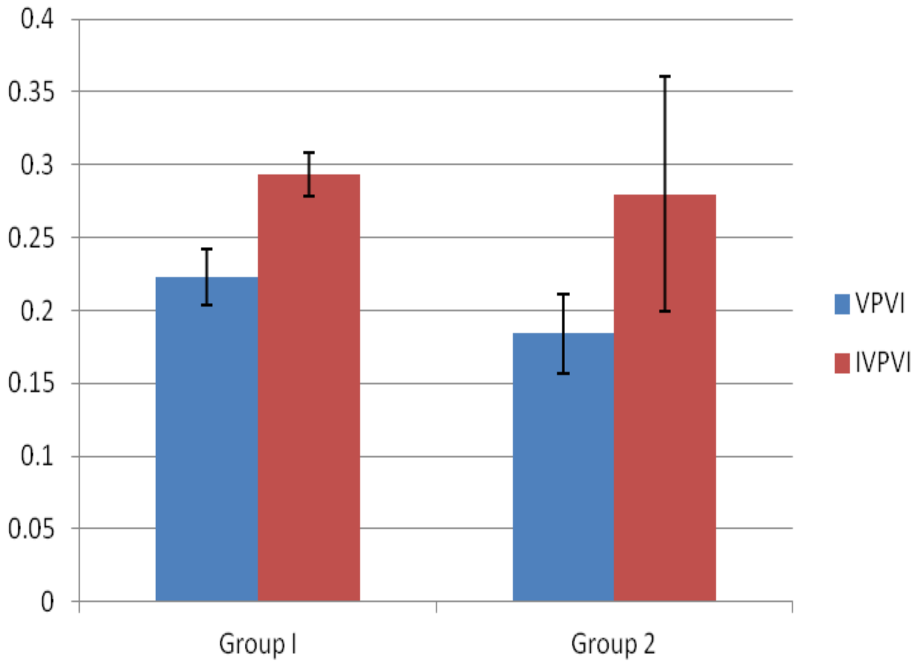

Figure 3: Mean and SD of PVIs for Group I and Group II

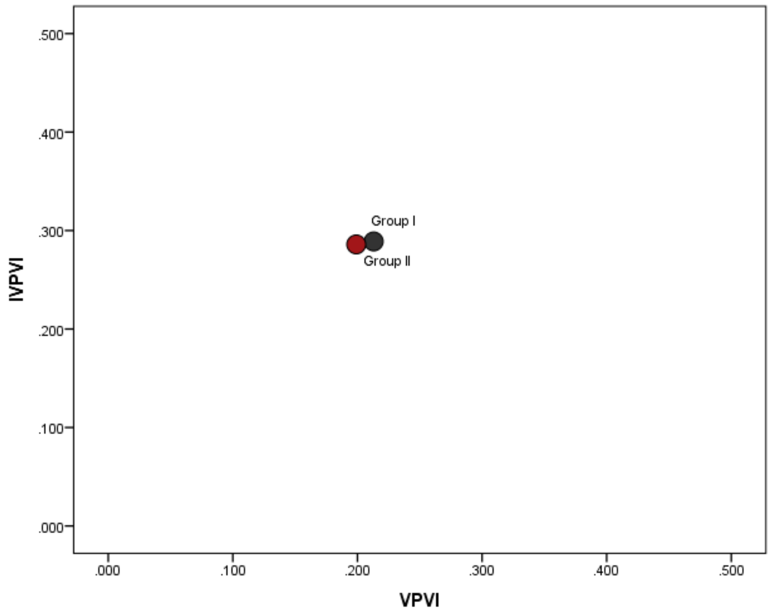

Figure 4: Comparison of PVI across Group I and Group II

(2) Individual data

In group I, Participant 1 has the lowest VPVI (0.205969) and Participant 3 has the highest VPVI (0.250931). Interestingly, the same participants have the lowest and highest values of IVPVI, i.e., Participant 1 have the lowest value (0.274561) and Participant 3 has the highest value (0.316708) of IVPVI.

In group II, Participant 3 has the lowest VPVI (0.140837) and Participant 2 has the highest VPVI (0.204921) while Participant 5 has the lowest IVPVI (0.204286) and Participant 2 has the highest IVPVI (0.409315). Table 4 shows the individual data of participants belonging to both the groups and shows the variations between participants. Figures 5 and 6 show the VPVI and IVPVI values of participants of both Group I and Group II.

Participants (P)	Group I		Group II	
	VPVI	IVPVI	VPVI	IVPVI
P1	0.205969	0.274561	0.203111	0.289885
P2	0.237755	0.284876	0.204921	0.409315
P3	0.250931	0.316708	0.140837	0.215213
P4	0.212012	0.2899	0.174428	0.286053
P5	0.213085	0.299702	0.199919	0.204286
Mean	0.22395	0.293149	0.184643	0.28095

Table 4: Individual data on PVIs in Group I and Group II

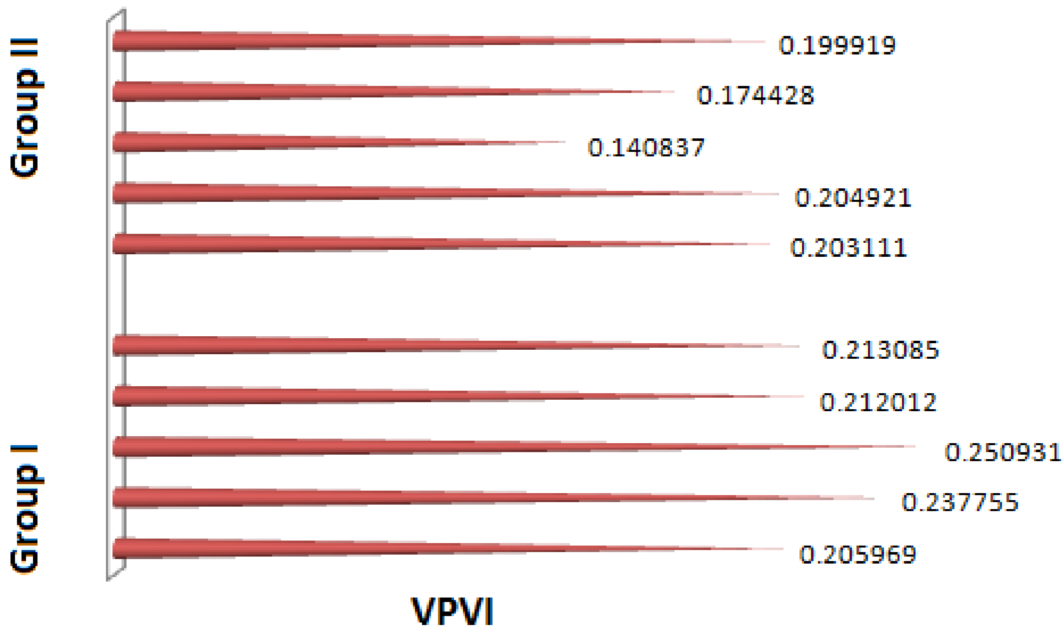

Figure 5: VPVI for participants of Group I and Group II

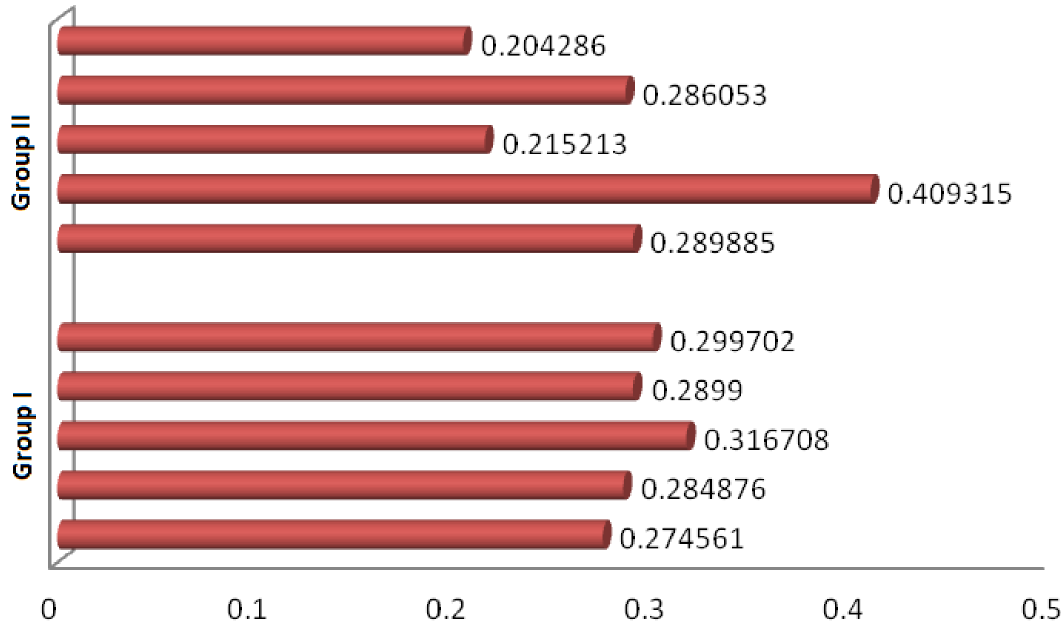

Figure 6: IVPVI for participants of Group I and Group II

The PVI values in group II was more scattered compared to that of group I. The scatter plots for both groups with VPVI on X-axis and IVPVI on Y-axis are depicted in figures 7 and 8.

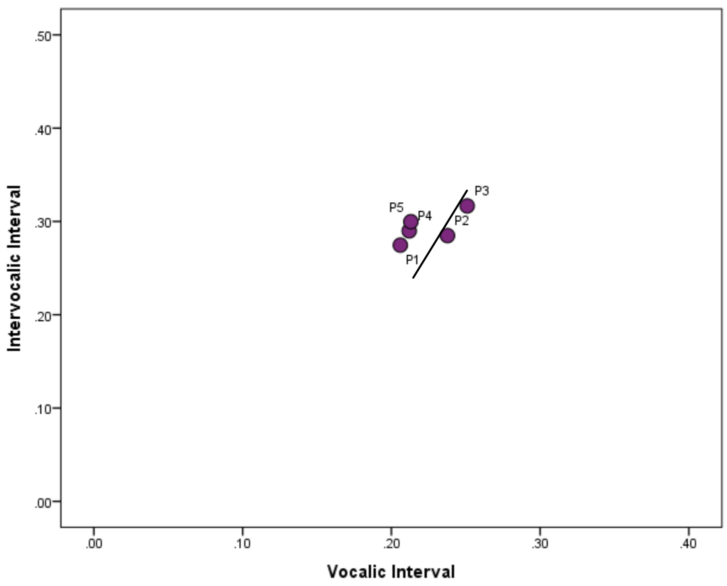

Figure 7: Scatter plot for PVI values in Group I

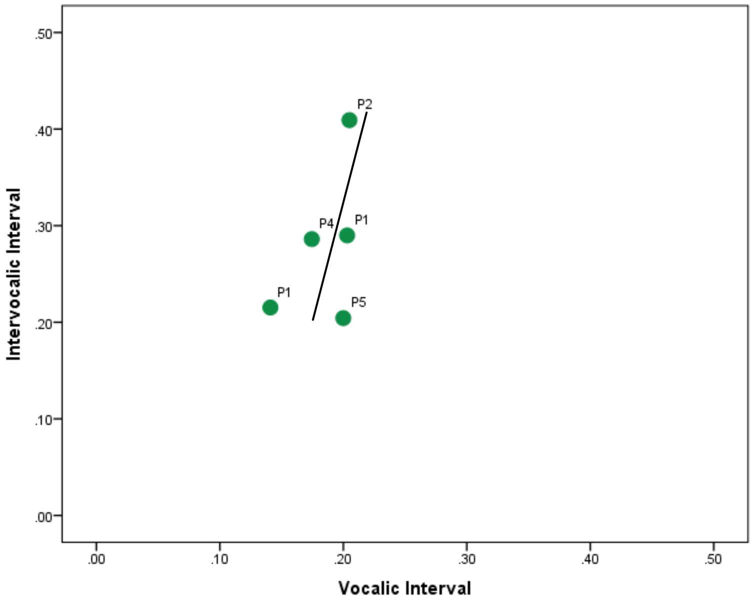

Figure 8: Scatter plot for PVI values in Group II

(3) Type of speech rhythm in Malayalam speaking children with and without hearing impairment

The results revealed that both VPVI and IVPVI in both groups were low. A PVI above 0.5 was considered as high and a PVI below 0.5 was considered as low. Hence, based on the data of the present study, the speech rhythm in both groups was classified as mora-timed.

To summarise, VPVI was significantly higher in group I compared to group II. Individual differences, interestingly more so in group II, were observed. The data indicated a mora-timed rhythm in 3-4 year old Malayalam speaking children with and without hearing impairment.

Chapter V

DISCUSSION

The results of the present study revealed several points of interest. ***First of all, VPVI was significantly higher in group I compared to group II***. Low VPVI could indicate that the same vocalic segments are used consistently whereas a high VPVI shows that there were more variations in the usage of vocalic segments such as short and long vowels. Greater difference in the durations of vocalic segments implies that the usage of types of vowels in the speech of children in group I was more and therefore, they may be still in the stage of acquiring language. Also, children in group I (hearing impairment) tend to prolong vowels, which support the results of studies by several authors (Angelocci, 1962; Calvert. 1962; John and Howarth, 1965; Boone, 1966; Levitt, Stromberg Smith, and Gold, 1974; Parkhurst and Levitt, 1978). Negligible difference in the intervocalic durations can be considered as a factor of age. Even typically developing children are slow to speak and they prolong the phonemes as they were still in the early stages of acquisition of speech rhythm (Post, and Watson, 1999; Whitworth, 2002; Bunta & Ingram, 2007; Savithri, Sreedevi, Deepa & Aparna, 2011). The participants of the present study were children of the age range 3-4 years, which explains the results.

Second, individual differences, interestingly more so in group II, were observed. An attempt was made to investigate the reasons for individual differences by calculating the frequency of occurrence of various vocalic and intervocalic segments used by children in the present study. However, no such correlations between type of intervals used and the measured PVI were evident. Table 5 shows the type of intervals used by children in the present study. Specifically the speech of participants who had lowest and highest PVI were investigated for the type of segment used.

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Group	Frequency of Vocalic Segments (%)		Frequency of Intervocalic Segments (%)		
I	**Short**	**Long**	**C**	**CC**	**CCC**
P1	74	26	69	29	2
P3	76	24	70	27	3
II					
P2	81	19	67	32	1
P3	86	14	66	33	1
P5	78	22	63	35	2

Table 5: Frequency of various intervals used by participants

Third, speech rhythm in participants of the present study was classified as mora-timed. According to rhythm class hypothesis a language with high PVIs can be classified to have stress-timed rhythm, low PVIs as mora-timed and high intervocalic PVI than vocalic PVI as syllable-timed. Lower values of the nPVIs for both the vocalic and intervocalic segments indicate that Malayalam speaking children had mora-timed rhythmic pattern. Indian studies on speech rhythm in children have been very few. Studies on typically developing Kannada speaking children have revealed that speech rhythm develops in children from the age range of 3-4 years till 11-12 years, when it approximates to the adult pattern (Savithri, 2013). The speech rhythm in 3-4 year old children with hearing impairment was found to be of mora-timed as they had lower VPVIs and IVPVIs. Similarly, the PVI values in the typically developing children in the present study were below 0.5, and therefore, were considered to be low. Hence, the rhythm was classified to be mora-timed.

Savithri et. al. (2007) investigated speech rhythm in 5-10 year old Kannada speaking children with hearing impairment and found mean vocalic and consonantal PVIs to be 67.1 and 20.5, respectively. The rhythm in these children remained unclassified as they had higher vocalic PVIs and lower intervocalic PVIs. The results of the present study showed a mora-timed pattern in Malayalam speaking children with and without hearing impairment as both PVI values were low. The extensive early intervention provided to the group with hearing impairment and the way speech is taught with stress on each syllable could possibly be a factor for such good performances as all of them were part of preschool for more than a year.

Results of study conducted by Savithri et. al. (2006) on speech rhythm in 12 Indian languages revealed that Malayalam speaking adults had mean nPVI and rPVI values of 44.9 and 48.4, respectively. Adults (18- 35 years) speaking Malayalam were reported to have syllable-timed rhythm based on the results of their study. In the present study children speaking Malayalam were found to have mora-timed rhythm. It could be speculated that Malayalam speaking children with hearing impairment have not yet acquired the adult-like pattern (syllable-timed rhythm) and that they are still in the developmental stage. Figure 9 compares speech rhythm in children with hearing impairment and typically developing children speaking Kannada (data taken from Savithri et. al., 2007) and Malayalam, and adults speaking Kannada (data taken from Savithri et. al., 2006). For the sake of comparison, median PVIs in the present study were multiplied by 100.

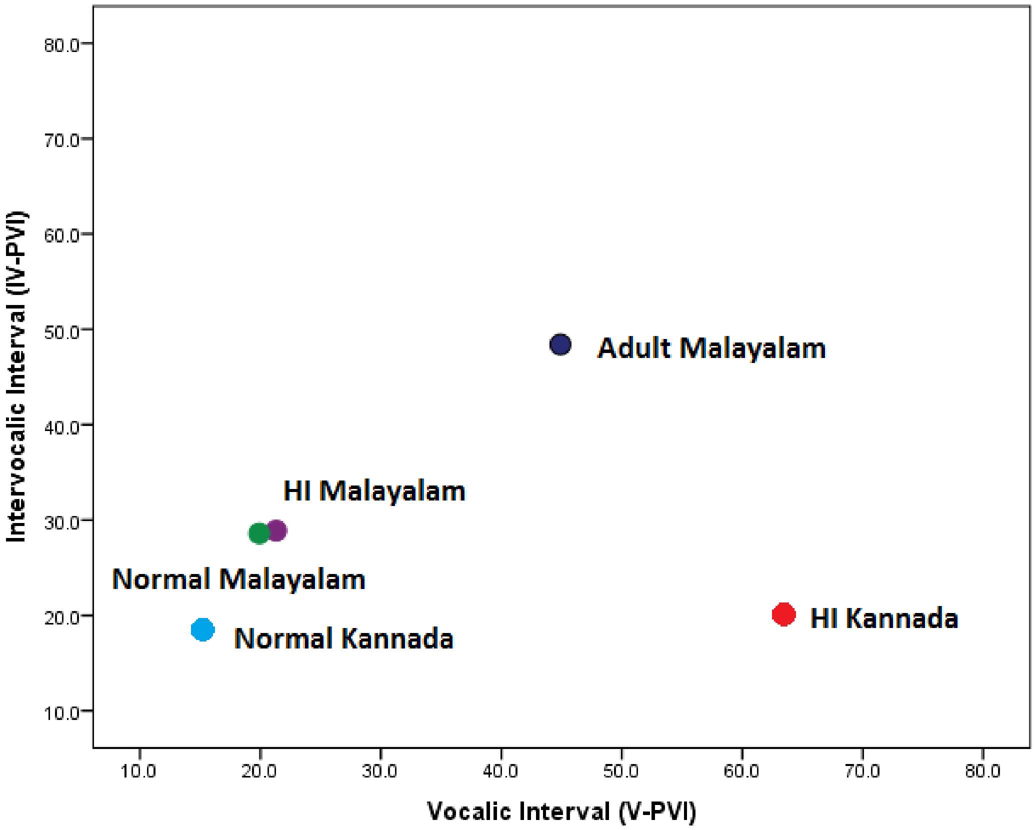

Figure 9: Comparison of PVIs in children with hearing impairment and typically developing children speaking Kannada (data taken from Savithri et. al., 2007) and Malayalam, and adults speaking Kannada (data taken from Savithri et. al., 2006).

The results of the present study were also compared with those of Low and Grabe (2000). Grabe and Low (2002) extracted vocalic and intervocalic PVIs of different languages of the world and reported stress-timed rhythm in British English, German, Dutch and Thai; syllable-timed rhythm in Tamil, Spanish, French, and Singapore English; mora-timed rhythm in Japanese and mixed rhythm in Polish and Catalan. Figure 10 was prepared based on the data given by Grabe and Low (2002) in their article on Durational Variability in Speech and the Rhythm Class Hypothesis and the data of the present study For the sake of comparison, median PVIs in the present study were multiplied by 100.

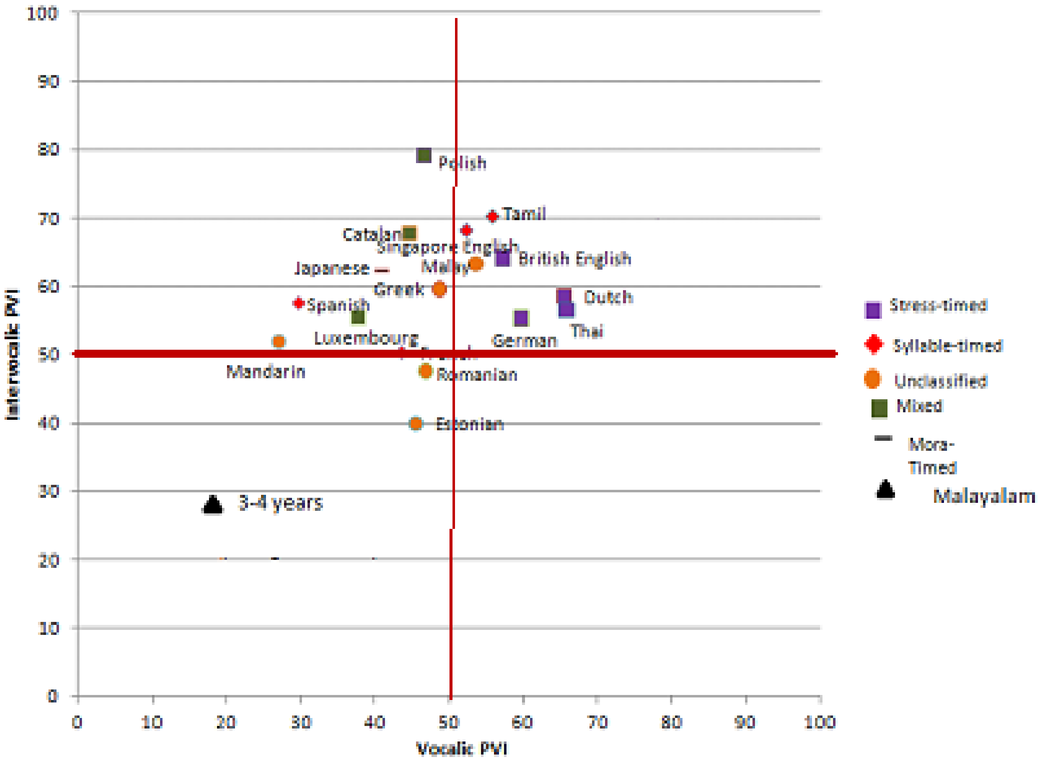

Figure 10: Vocalic and intervocalic PVIs in the present study and other languages of the world (taken from Low & Grabe, 2000)

Comparing the data on PVIs in Malayalam with various languages of the world, one can observe that rhythm in 3-4 year olds in the present study was not close to any language in the world except Kannada as shown in figure 10. Horizontal and vertical red lines are drawn in the figure to indicate low and high. Those on the bottom left quadrangle can be considered to have low VPVI and IVPVI (mora-timed rhythm). Those on the top right quadrangle can be considered to have high VPVI and IVPVI (stress-timed rhythm). Those on the left top quadrangle can be considered to have low VPVI and high IVPVI (syllable-timed rhythm) (1). Grabe and Low classified English, Dutch, and German as stress-timed languages, French and Spanish as syllable-timed languages and Japanese as mora-timed language. Considering the basis of classification as in (1) above, Mandarin, Romanian and Estonian can be classified to have mora-timed rhythm; Tamil, British English, Malay, Thai, Dutch and

German as stress-timed rhythm; Polish, Catalan, Singapore English, Japanese. Spanish, Luxembourg, Greek as syllable-timed rhythm. According to this, some classifications done by Grabe and Low appear to be not in order or the basis of classification (meaning of high and low) is unknown.

The results of the present study have added to the existing evidence on the speech rhythm in children with hearing impairment. This is the first study on speech rhythm in Malayalam speaking children with and without hearing impairment. The results of the study could have some clinical implication in the assessment and treatment of Malayalam speaking children with hearing impairment. Rhythm is one of the most important prosodic features which are ignored during assessment and treatment. But studies show that the rhythm largely contributes to speech intelligibility. The results of the present study could possibly promote the objective assessment of rhythm of different communication disorders and can be used as a reference for assessment. It also enlightens on the need to emphasize on the integration of speech rhythm during communication interventions and to use the same for tracking progress. Mora-timed rhythm can be taught to Malayalam speaking children of 3-4 years of age with arrhythmia. The durational differences between syllables are negligible in a mora-timed rhythmic pattern. The concept can be taught using modelling, imitation and other techniques. The current study was a preliminary attempt to investigate speech rhythm in Malayalam speaking children with and without hearing impairment. To gain an in-depth knowledge regarding the same, a detailed study across age groups, employing different rhythm metrics and varied tasks is warranted. Cross-linguistic studies on children with hearing impairment will also be interesting.

Chapter VI

SUMMARY AND CONCLUSIONS

The present study investigated the speech rhythm in Malayalam speaking children with and without hearing impairment. Group I included 5 children with hearing impairment (severe-profound) and group II included 5 typically developing children of the language age of 3-4 years. Speech samples were recorded using a picture description task with the help of simple pictures in the fluency test developed by Nagapoornima (1990) in 3-4 year old children. The recorded samples were edited and the Pairwise Variability Index (PVI) values for vocalic and intervocalic segments were calculated using Microsoft Excel. Descriptive and Inferential (Mann-Whitney test) Statistical analysis was carried out on SPSS Software (version 20). The results revealed a significantly higher VPVI in group I compared to group II. The rhythm type was classified as mora-timed in both groups speaking Malayalam. The results of the present study have added to the existing evidence on the speech rhythm in children with hearing impairment. This is the first study on speech rhythm in Malayalam speaking children with and without hearing impairment. The results of the study could have some clinical implication in the assessment and treatment of Malayalam speaking children with hearing impairment. Rhythm is one of the most important prosodic features which are ignored during assessment and treatment. But studies show that the rhythm largely contributes to speech intelligibility. The results of the present study could possibly promote the objective assessment of rhythm of different communication disorders and can be used as a reference for assessment. It also enlightens on the need to emphasize on the integration of speech rhythm during communication interventions and to use the same for tracking progress. Mora-timed rhythm can be taught to Malayalam speaking children of 3-4 years of age with arrhythmia. The durational differences between syllables are negligible in a mora-timed rhythmic pattern. The concept can be taught using modelling, imitation and other techniques. The current study was a preliminary attempt to investigate speech rhythm in Malayalam speaking children with and without hearing impairment. To gain an in-depth knowledge regarding the same, a detailed study across age groups, employing different rhythm metrics and varied tasks is warranted. Cross-linguistic studies on children with hearing impairment will also be interesting.

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