# DEVELOPMENT OF SPEECH RHYTHM IN KANNADA SPEAKING CHILDREN

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## Abstract

*Rhythm in speech is the systematic organization of speech units in time, such as syllables and vocalic intervals. Language of the world has been organized under stress-timed, syllable – timed and mora-timed, depending on the type of syllables used in a language. The present study is initially output of large scale study which to investigated the development of speech rhythm in typically developing Kannada speaking children by using the pair-wise Variability Index (PVI). Total of 15 boys, were divided in to three age groups (4-5, 8-9 and 11-12 years) with an equal number of participants. A five-minute of narrated speech sample of each child was elicited using cartoons or Panchatantra pictures. All the samples were audio-recorded using Olympus digital voice recorder at a sampling frequency of 16 kHz. Each speech samples were audio listened carefully removed the pauses manually. The Vocalic (V) and Intervocalic (IV) durations were measured in the samples using PRAAT software. The duration difference between successive vocalic and intervocalic segments was calculated and averaged to get the normalized Pair-wise Variability Index (nPVI) and raw Pair-wise Variability Index (rPVI), respectively. The result indicated that segmental timing showed a developmental trend in children and the boys begin to adult-like rhythm at around 11-12 years. Due to the high nPVI and low rPVI values the rhythmic pattern remains unclassified and cannot be placed in any of the rhythmic classes. The findings reveal that the syllabic structure used by children is different (prolonged vowel duration) from the adults.*

***Key words**: **Speech rhythm, Vocalic duration, Intervocalic duration, Pair wise Variability Index.***

Rhythm, a prosodic feature, refers to an event repeated regularly over a period of time. Rhythm in speech is the systematic organization of prominent and less prominent speech units in time, such as syllables and vocalic intervals (Abercrombie, 1967). Rhythm varies with languages and depends on the types of syllables used in a language. Languages differ in characteristic rhythm, and with respect to adult speakers, they have been organized under stress-timed, syllable-timed and mora-timed, based on the Rhythm Class Hypothesis (Abercrombie, 1967). The Rhythm Class Hypothesis states that each language belongs to one of the prototypical rhythm classes known as stress-timed, syllable-timed or mora-timed (Ladefoged, 1975).

When a language has simple syllabic structure, for e.g. VC or CCV, the durational difference between the simplest and most complicated syllable is not wide. This durational difference may be less than 330ms. Under these circumstances, the rhythm of the language is said to be a fast **syllable-timed rhythm**. If the syllabic structure is still simpler, for e.g. VC or CV, then the durational difference between syllables is negligible and it is called a **mora-timed language**. When a language has complex syllabic structure, for e.g. V and CCCVCC, the difference between syllables can be very wide. In such a condition one has to use a slow **stress-timed rhythm** (Abercrombie, 1967).

The development of concept on rhythm measurement was started with the concept of isochrony- i.e. each syllable has equal duration or the occurrence of regular stress beats. The first attempt to test Rhythm Class Hypothesis (Grabe &

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Low, 2002) by using the ***average syllable duration (ms)***, but was not found to be effective in classifying rhythm types. Roach (1982) used a different measure – ***inter-stress interval*** (ISI). However, ISI also does not seem to classify all languages on the basis of rhythm. Ramus, Nespor and Mehler (1999) measured and found that a combination (vector) of **vocalic *durations*** (%V) and ***SD of consonant intervals*** (△C) provided the best acoustic correlate of rhythm classes. These measures reflected rhythmic differences as continuum, but not classes.

The **Pair-wise Variability Index (PVI)** was developed by Low (1998) for rhythmic analysis. This is a quantitative measure of acoustic correlates of speech rhythm and it calculates the patterning of successive vocalic and intervocalic (or consonantal) intervals, showing how one linguistic unit differs from its neighbor. The normalized Pairwise Variability Index (nPVI) and raw Pairwise Variability Index (rPVI) was developed by Low, Grabe and Nolan (2000). nPVI is used for rhythmic analysis of vocalic durations and rPVI is used for rhythmic analysis of intervocalic durations. Since it is a ratio it does not have any unit. Using the nPVI and rPVI value majority of the languages was classified successfully in comparison with other measures of rhythm. The classification of languages according to nPVI and rPVI is based on the following pattern shown in Table 1. Classifying the rPVI and nPVI value as ***high or low*** is in comparison with each other.

| | Intervocalic interval (IV) rPVI | Vocalic interval (V) nPVI |
|---|---|---|
| Stress-timed | High | High |
| Syllable-timed | High | Low |
| Mora-timed | Low | Low |

Table 1: Classification of rhythm patterns based on the Vocalic and Intervocalic intervals.

In the Indian context, the research done so far is mostly on adults and much needs to be done on speech rhythm in children. Savithri, Sanjay Goswami and Kedarnath (2007) investigated rhythm in Kannada speaking adults and results showed that Kannada is a mora-timed language (low rPVI and nPVI). The rPVI values for the reading sample ranged between 35.90 and 52.10 with a mean of 46.18 and nPVI values ranged between 41.80 and 54.36, with a mean of 46.95.

With respect to children, few studies have been carried out recently. Subhadra, Das and Singh (2009) examined the rhythmic features of speech in 70 bilingual children speaking English and Hindi between 5 and 8 years. They found that at around 7 years of age, the durational variability for English became significantly larger than that of Hindi and suggested that children learning two languages exhibit characteristic speech rhythm around 7 years of age. A study by Savithri, Sreedevi and Kavya (2009) investigated the type of speech rhythm in typically developing 8-9 year old Kannada speaking children. The rPVI values for these children ranged between 44.97 to 78.17 with a mean of 65.90 and the nPVI values ranged between 80.10 to 122.75 with a mean of 96.06.

The results of above studies reported high nPVI and low rPVI values for adults as well as for children in Kannada language and therefore the rhythmic pattern remained ***unclassified.*** The results also showed that syllabic structure used by the children was simpler than adults. These reports give interest in investigating the trend of change in the rPVI and nPVI values across age groups. This intern will help to in known the syllabic structure changes in the spoken language across age groups which will help in assessment and management of children with arrhythmia. Hence there is a need to investigate the development of speech rhythmic pattern in children. In this context the present study was undertaken. The present paper is a part of the DST project and investigated the development of speech rhythm in typically developing Kannada speaking children across the age and gender in large samples. The present study shows the result of three age groups of participants.

## Method

***Participants*:** A total of 15 boys participated in the study. Participants were divided into three groups according to their age. Group I consisted of 5 boys in the age range of 4-5 years; Group II consisted of 5 boys in the age range of 8-9 years and Group III consisted of 5 boys in the age range of 11-12 years. All the participants were screened by the speech-language pathologist for speech and hearing problem. Ling test was used for hearing screening and the standardized questioner developed by department of Prevention of communication disorder,

All India Institute of Speech and Hearing was used to screen the speech and language problem.

***Material*:** Cartoons developed by Indu (1990) were used for children of Group I. Children in Group II and III described Panchatantra pictures developed by Rajendra Swamy (1992).

***Procedure*:** Speech samples were collected in quiet room of schools in Mysore. A five-minute of narrated speech sample of each child was elicited using cartoons or Panchatantra pictures. From Group I children speech was elicited using prompts and repetitions. All the samples were audio-recorded using Olympus digital voice recorder at a sampling frequency of 16 kHz.

***Analyses*:** Speech samples were displayed as waveform using the PRAAT software (Boersma & Weenink, 2004, version 5.0.34). They were heard carefully to identify pauses which were removed manually. This was done in order to get an appropriate measure of the vocalic and non-vocalic segments. The Vocalic (V) and Intervocalic (IV) durations were measured in the samples using PRAAT software. Vocalic measure refers to the duration of vowel/ semivowel/ diphthong that will be measured as the time duration from the onset of voicing to the offset of voicing for that vowel/ semivowel/ diphthong. Intervocalic measure refers to the duration between two vocalic segments. It was measured as the time duration between the offset of the first vocalic segment to the onset of the second vocalic segment. Figure 1 shows the illustration of vocalic and intervocalic measures in the sentence [ondu:ralli ondu ka:ge ittu].

The duration difference between successive vocalic and intervocalic segments was calculated and averaged to get the nPVI and rPVI, respectively. Pairwise Variability Index developed by Low, Grabe and Nolan (2000) was used as a measure of rhythm. The rPVI and nPVI were measured using the following formulae:

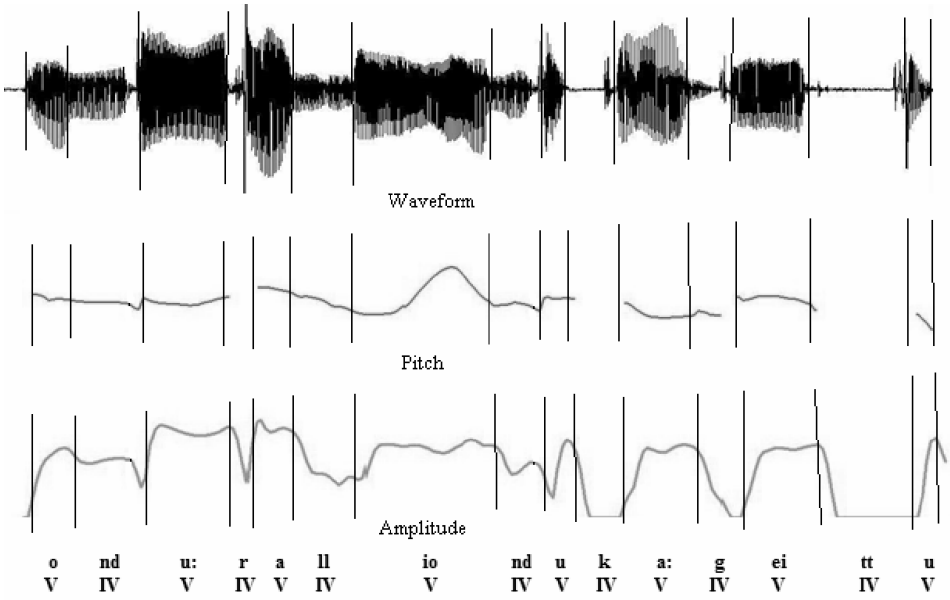



Figure 1: Illustration of measurement of vocalic (V) and intervocalic (IV) intervals in the sentence [ondu: ralli ondu ka:ge ittu]

$$rPVI = \frac{100}{m-1} \times \left( \sum_{k=1}^{m-1} \left| \frac{d_k - d_{k+1}}{(d_k + d_{k+1})/2} \right| / (m-1) \right)$$

where, m is the number of intervals and $d_k$ is the duration of the $k^{th}$ interval.

$$nPVI = \frac{100}{m-1} \times \left( \sum_{k=1}^{m-1} \left| d_k - d_{k+1} \right| / (m-1) \right)$$

where, m is the number of intervals and $d_k$ is the duration of the $k^{th}$ interval.

***Statistical analysis:*** Microsoft Office Excel program was used to generate the formula and calculate the difference between successive vocalic and intervocalic segments and to obtain the nPVI and rPVI values. Mann Whitney-U test was used to obtain the significant differences between the groups.

| Sub. No. | Group I (4-5 yrs) | | Group II (8-9 yrs) | | Group III (11-12 yrs) | |
|---|---|---|---|---|---|---|
| | rPVI | nPVI | rPVI | nPVI | rPVI | nPVI |
| 1. | 51.55 | 119.5 | 62.13 | 91.22 | 46.64 | 68.2 |
| 2. | 49.75 | 96.07 | 48 | 96.4 | 36.63 | 74.02 |
| 3. | 92.58 | 86.92 | 66.57 | 112.8 | 37.88 | 78.8 |
| 4. | 74.34 | 92.46 | 63.21 | 108.24 | 42.04 | 67.52 |
| 5. | 66.74 | 83.41 | 63.22 | 83.72 | 41.63 | 71.11 |
| Median | 66.74 | 92.46 | 63.21 | 96.40 | 41.63 | 71.11 |
| (SD) | (17.63) | (14.18) | (7.25) | (11.99) | (3.94) | (4.62) |
| Confidence Interval (95%) | 45-88.8 | 78-113.2 | 51.6-96.6 | 83.5-113.3 | 36-45.8 | 66.1-77.6 |

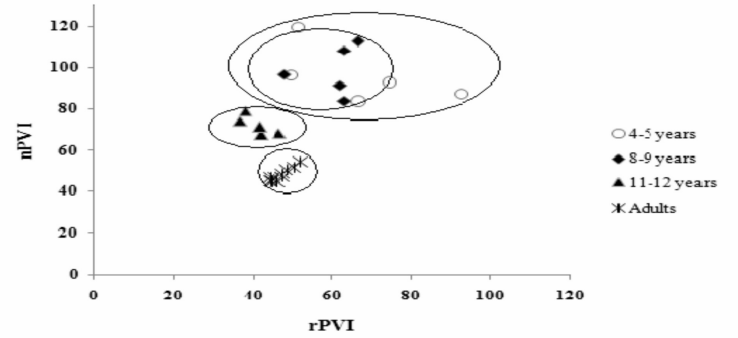
Table 2: Mean rPVI and mean nPVI of the five male subjects across three age groups.

**Results and Discussion**

The mean rPVI of Group I ranged between 49.75 to 92.58 and the mean nPVI ranged between 83.41 to 119.5. The mean rPVI of Group II ranged between 48.0 to 66.57 and the mean nPVI ranged between 83.72 to 112.8. The mean rPVI of Group III ranged between 36.63 to 46.64 and the mean nPVI ranged between 67.52 to 78.8. The mean nPVI was found to be higher than the mean rPVI in all the three groups. Table 2 and the figure 2 shows the rPVI and nPVI values of all the subjects.

Results of Mann Whitney-U test indicated no significant difference between group I and II for rPVI [$|Z| = 0.94$, $p > 0.01$] and nPVI [$|Z| = 0.52$, $p > 0.01$]. Significant differences between group II and III for rPVI [$|Z| = 2.61$, $p = 0.01$] and nPVI [$|Z| = 2.61$, $p = 0.01$] and between group I and III for rPVI [$|Z| = 2.61$, $p = 0.01$] and nPVI [$|Z| = 2.61$, $p = 0.01$] were found. The results revealed several points of interest. First, the results indicated that nPVI was higher than the rPVI values in all the three groups. This is in not consonance with the findings by Savithri, Sanjay Goswami and Kedarnath (2007) where they have used reading task for speech rhythm analysis in adults speaking Kannada. Current study showed high value of nPVI value which may be because of of longer durations of vocalic segments. This implies that children (boys) in the present study tend to prolong the vowel to a greater extent, which had effect on nPVI compared to adults. Another reason can be the difference in the task one being reading and another being narration. Narration of pictures requires more time (to form a sentence) which might have caused lengthening of vowels in children's speech.

Second, the results of the present study revealed no significant difference between 4-5 years and 8-9 year old children. But there was a significant difference between 8-9 years and 11-12 year old children. The nPVI and rPVI were shorter in boys in the age range of 8-9 years compared to 11-12 year old boys. The nPVI value of boys in the age range of 11-12 years was closer to adults (Savithri, Sanjay Goswami & Kedarnath, 2007). This shows that the boys begin to acquire an adult-like rhythm at around 11-12 years. These findings support the results of several studies by Smith (1978), Lee, Potamianos and Narayanan (1999), Smith and Kenney (1999) which indicate that 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.




(Adult data is from Savithri, Sanjay Goswami and Kedarnath, 2007)

Figure 2: Mean of nPVI and rPVI values for children of the three age groups vs. adults.

Third, the rhythm in boys in the present study showed high nPVI value and Low rPVI value which remains 'unclassified'. This is not in consonance with the results of the study in Kannada speaking adults by Savithri, Sanjay Goswami and Kedarnath (2007) which indicated that Kannada was a mora-timed language. This result generated doubts whether rhythm needs to be classified under the three types. Probably, there may be many more types of rhythm. Also, should the measurement of rhythm needs to be further investigated or whether the rhythm measurements should be based only on durations or should it be based on other acoustic correlates of prominence, namely increased $F_0$, increased amplitude and changed vowel quality. Kohler, 2009 reported that rhythm is not a fixed typological prominence pattern for groups of language but is variable within each language. However it is also determined by the language in that the potential rhythmical patterns of F0, syllabic duration, energy and spectral patterning over time.

Fourth, it was observed that the PVI variability (SD) was larger in the younger age groups compared to the older age group and it decreased from 4-5 years to 11-12 years of age. Most of the time the variability was higher in nPVI compared to rPVI. These results support the findings of Lee, Potamianos and Narayanan (1999), who report that between the ages 9 and 12, both magnitude and variability of segmental durations decrease significantly and rapidly, converging to adult levels around age 12.

The study intends to investigate the development of speech rhythm in typically developing Kannada speaking children from 3 to 12 years of age. Hence, it is anticipated that a picture of emerging rhythm will appear when the study is complete.

## Conclusions

Speech rhythm refers to the alternation of timing and the perceived regularity of prominent units in speech, and its acquisition provides valuable insights into how children learn their languages. The present study investigated the development of speech rhythm in typically developing Kannada speaking children by measuring the vocalic and intervocalic intervals. The results of the present study indicated that children appear to produce durational and other prosodic differences as early as 4-5 years, but their productions are characteristically variable until much later, stabilizing to more or less adult-like rhythmic patterns around 11-12 years of age. This study reveals that the syllabic structure used by children is different from the adults and there is a need to develop normative data to map the pattern in which they acquire adult-like speech rhythm.

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