SPEECH RHYTHM IN KANNADA SPEAKING CHILDREN

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Abstract

*Rhythm is a systematic temporal and accentual patterning of sound. Speech rhythm refers to the way languages are organized in time. The present study investigated the differences in the type of speech rhythm, in typically developing, Kannada speaking children in the age groups of 3-4 years, 8-9 years, and 11-12 years. Sixty children (10 girls and 10 boys in each of the three age groups) participated in the study. A five-minute speech sample was elicited using simple pictures/cartoons developed by Nagapoornima (1990) in 3-4 year old children; for children in the older age groups, pictures depicting simple stories developed by Rajendra Swamy (1991) adapted from Panchatantra were used. These speech samples were analyzed using PRAAT 5.1.14 software. Vocalic (V) and Intervocalic (IV) durations were measured. The durational difference between successive vocalic and intervocalic segments were calculated and averaged to get Pair wise Variability Index. Comparison of PVIs of the above age groups with Kannada speaking adults indicated that 3-4 year old children had syllable-timed rhythm pattern; 8-9 year and 11-12 year old children was mora-timed rhythm. Intervocalic PVI reduced from younger to older age group whereas vocalic PVI showed no such trend. Results obtained are discussed with reference to the rhythm types in each age group and establishing a continuum in development of spe*ech rhythm.

Key words: *Speech Rhythm, Vocalic, Intervocalic, Pair wise Variability Index, mora-timed, syllable-timed.*

Rhythm is the systematic patterning of timing, accent and grouping in sequences of events. The study of speech rhythm has become a key challenge in speech technology since most of automatic speech processing systems have to cope with the variability of speech rate and rhythm and their consequences both on the segmental units and suprasegmental organization of speech. Languages differ in characteristic rhythm (Pike, 1945; Abercrombie, 1967) though no consensus has emerged on how the undoubted differences in rhythmic structures should be captured (Cutler, 1991). 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.

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 330 ms.   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 the rhythm of such language is a mora-timed language. When a language has complex syllabic structure, for e.g. V and CCCVCC, the durational difference between syllables can be very wide. In such a condition one has to use a slow stress-timed rhythm.

The development of concept on rhythm measurement initiated with the concept of isochrony i.e. successive syllables are said to be of near-equal length or interval between stresses are said to be equal in length. The first attempt to test Rhythm Class Hypothesis was made by Abercrombie (1967) by using the average syllable duration, but was found not to be effective in classifying rhythm types. Roach (1982) used a different measure − inter-stress interval (ISI). However, ISI also did not seem to classify languages on the basis of rhythm. Ramus, Nespor & Mehler (1999) found that a combination of vocalic durations (% V) and Standard Deviation of consonant intervals (ΔC) provided the best acoustic correlate of rhythm classes.

The Pair-wise Variability Index (PVI) is a quantitative measure of acoustic correlates of speech rhythm which calculates the patterning of successive vocalic and intervocalic (or consonantal) intervals, showing how one linguistic unit differs from its neighbour (Low, 1998). The PVI can be calculated "raw" (intervocalic PVI), where the differences between successive pairs of units are averaged. The raw Pairwise Variability Index (intervocalic PVI) is used for rhythmic analysis of intervocalic durations. Low, Grabe & Nolan (2000) developed normalized Pairwise Variability Index (vocalic PVI) for rhythmic analysis of vocalic durations. Normalisation involves expressing each difference as a proportion of the average of the two units involved. Table 1 summarizes the basic characteristics of each language class regarding relative values of vocalic PVI and intervocalic PVI.

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Table 1: *Summary of basic characteristics of rhythm class based on vocalic PVI and intervocalic PVI.*

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

In the Indian context, the data collected so far is mostly on adults and data on speech rhythm in children are limited. Savithri, Jayaram, Kedarnath & Goswami (2006) found Kannada[†] to be a mora-timed language (low PVIs) in adults. They report intervocalic PVI values between 35.90 and 52.10 with a mean of 46.18 and vocalic PVI values between 41.80 and 54.36, with a mean of 46.95 in reading samples.

Savithri, Johnsirani & Ruchi (2008) studied speech rhythm in normal and hearing-impaired children in the age range of 5-10 years. The mean PVI values for normal children were 15.70 (intervocalic) and 62.49, whereas for the hearing-impaired children, (intervocalic) they were 20.54 and 67.14, respectively. The results indicated high vocalic PVI and low intervocalic PVI values in both the groups. Therefore, the rhythm pattern remained unclassified and could not be placed in any of the rhythmic classes (stress-timed, syllable-timed, or mora-timed). The results also showed that syllabic structure used by the children was simpler in the acquisition stage of rhythm patterns. Hence there is a need to develop normative data for understanding the development of rhythm pattern in children.

Savithri, Sreedevi, Deepa & Aparna (2011) investigated the rhythm in 3-4 year old typically developing children. The results showed that mean vocalic PVI was 61.27 and mean intervocalic PVI was 77.82. In this group, rhythm wais classified as syllable-timed as the mean intervocalic PVI was more than mean vocalic PVI. On similar lines the same authors investigated rhythm in 11-12 year old Kannada speaking girls and found high vocalic PVI (60.75) and the low intervocalic PVI (53.72).

[†] Kannada is one of the major Dravidian languages of India, spoken predominantly in the state of Karnataka. Native speakers are called Kannadigas, number roughly 50 million, making it the 27th most spoken language in the world. It is one of the scheduled languages of India and the official & administrative language of the state of Karnataka. Kannada (n.d) *In Wikipedia Online. Retrieved from http://www. wikipedia.com.*

However, the difference was not significant and the rhythm was mora-timed.

The present paper is a part of a project which investigated the differences in the type of speech rhythm, if any, between typically developing 3-4 year, 8-9 year, and 11-12 year old Kannada speaking boys and girls.

Method

Subjects: Sixty native Kannada speaking, typically developing children in the age range of 3-4 years, 8-9 years, and 11-12 years (10 girls and 10 boys in each age group) participated in the study. All subjects were screened to rule out structural and/or functional deficits in speech, language, and hearing.

Test Material: A five-minute speech sample was elicited from each subject. Simple pictures/cartoons developed by Nagapoornima (1990) were used in 3-4 year old children. Pictures depicting simple stories developed by Rajendra Swamy (1991) adapted from Panchatantra were used for children in the older age groups (8-9 years and 11-12 years).

Procedure: Speech samples were collected from one subject at a time. They were instructed to see the pictures carefully and describe them. Prompting was used at times when the child did not respond. Speech samples were audio-recorded using a digital voice recorder (Olympus-WS-100) at a sampling frequency of 16 kHz.

Acoustic analyses: The speech samples were transferred onto the computer and analyzed using PRAAT 5.1.14 software (Boersma & Weenik, 2009). The pauses were eliminated by using the same software. This was done in order to get an appropriate measure of the vocalic and intervocalic segments. The Vocalic (V) and Intervocalic (IV) segments were highlighted using a cursor and durations were measured. Vocalic measure refers to the duration of a vowel/semivowel/diphthong which was measured as the time difference between the onset of voicing to the offset of voicing for that vowel/semivowel/diphthong. Intervocalic measure refers to the time difference between two vocalic segments. It was measured as the time difference between the offset of the first vocalic segment to the onset of the second vocalic segment. Figure 1 illustrates vocalic and intervocalic measures in the Kannada sentence [ondu:ralli ondu ka:ge ittu].
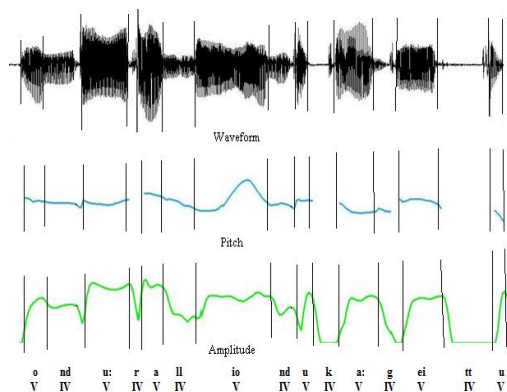
Figure 1: *Illustration of measurement of vocalic (V) and intervocalic (IV) intervals in the sentence [ondu:ralli ondu ka:ge ittu].*

The duration difference between successive vocalic and intervocalic segments were calculated and averaged to get the PVIs. Pairwise Variability Index developed by Grabe & Low (2002) was used as a measure of rhythm. The PVIs were calculated using the following formulae:

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

Where, m is the number of intervals and d_k is the duration of the kth interval. PVIs were calculated using the above formulae in the Microsoft office excel program.

Statistical Analysis: Statistical analysis was carried out using commercially available SPSS (version 16) software. Mixed ANOVA was used to find the overall interaction between age, gender and the PVIs. T-test was used to find the significant difference between PVIs in each age group for boys and girls. Multivariate analysis was used to obtain the significant difference within the gender for PVIs across age groups.

Results and Discussion

3-4 year old children: The vocalic PVI for girls ranged between 39.09 to 76.68 with a mean of 59.38 and the intervocalic PVI ranged from 74.05 to 91.49 with a mean of 85.22. The vocalic PVI in boys ranged between 46.28 to 96.17 with a mean of 63.16 and the intervocalic PVI ranged from 61.54 to 81.63 with a mean of 70.43. The intervocalic PVI was significantly higher [t (19) = 3.995; p < 0.01] than the vocalic PVI in both the genders. The mean vocalic PVI was 61.27 and the mean intervocalic PVI was 77.82. Hence the rhythm can be classified as syllable timed in this age group. Figure 2 shows PVIs in both girls and boys.
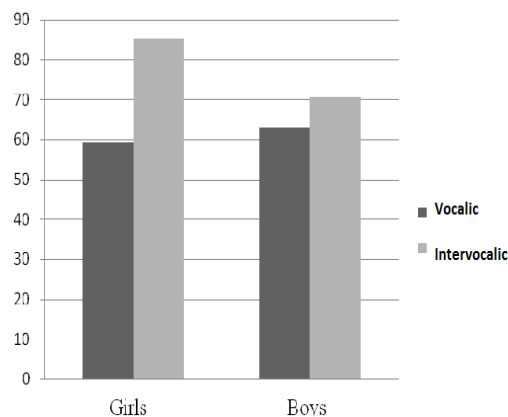

Figure 2: *PVI values in 3-4 year old girls and boys.*

8-9 year old children: Vocalic PVI values in girls ranged between 47.49 to 90.55 with a mean of 57.07 and intervocalic PVI values ranged from 41.37 to 79.45 with a mean of 54.54. vocalic PVI values in boys ranged from 49.45 to 63.37 with a mean of 58.78 and intervocalic PVI values ranged from 41.22 to 69.10 with a mean of 54.33. Though mean vocalic PVI was higher than intervocalic PVI the difference was not significant [t (19) = 0.295, p > 0.05]. Hence, rhythm can be classified as mora-timed. Figure 3 shows intervocalic PVI and vocalic PVI values in 8-9 year old girls and boys.
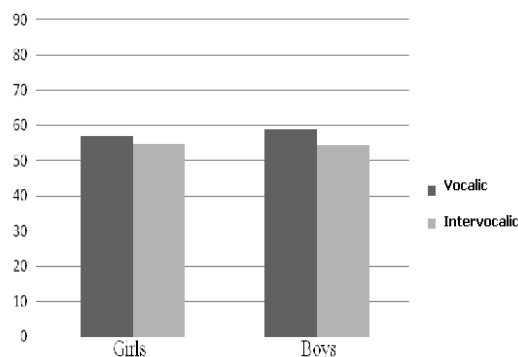

Figure 3: *Intervocalic PVI and vocalic PVI values in 8-9 year old girls and boys.*

11-12 year old children: The vocalic PVI values for girls ranged from 37.0 to 84.09 with a mean of 60.75 and the intervocalic PVI values ranged from 38.3 to 84.01 with a mean of 53.72. The vocalic PVI values in boys ranged between 44.62 to 69.51 with a mean of 59.73 and the intervocalic PVI values ranged from 38.3 to 84.01 with a mean of 43.12. The results indicated higher vocalic PVI compared to intervocalic PVI in both the genders. However, the difference was not significant (t (29) = 1.808; p > 0.05). Hence, rhythm can be classified as mora-timed. Figure 4 shows vocalic PVI and intervocalic PVI values in 11-12 year old girls and boys.
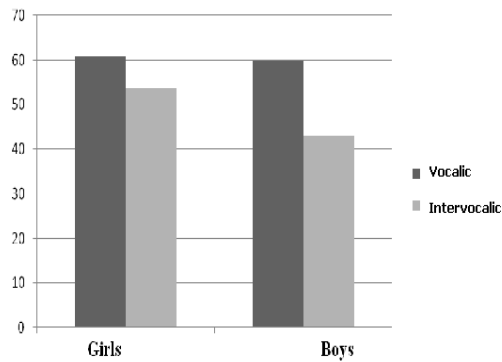
Figure 4: *Intervocalic PVI and vocalic PVI values in 11-12 year old girls and boys.*

Results of mixed ANOVA indicated significant difference between age groups [F (2) = 40.05; p < 0 .05], and gender [F (1) = 5.123; p < 0.05]. Results of Bonferroni multiple comparison, showed that 3-4 years had significantly (p < 0.001) higher PVI values than the older age groups. Mean PVI values of 8-9 years was higher

than 11-12 years but the difference was not significant (p > 0.05).

Results of multivariate analysis indicated a significant difference for intervocalic PVI for both the genders across age groups [F (2) = 0.993; p < 0.001] and no significant difference in vocalic PVI for both the genders, across age groups [F (2) = 0.958; p > 0.05]. intervocalic PVI in 3-4 year old boys were significantly higher than that in 8-9 and 11-12 year old boys; 8-9 year old boys significantly higher than that in 11-12 year old boys. In girls, intervocalic PVI was significantly higher in 3-4 years compared to older age groups. The mean intervocalic PVI value was higher in 8-9 year old girls compared to 11-12 year old girls but the difference was not significant (p > 0.05). However, intervocalic PVI decreased from 3-4 years to 11-12 years in both the genders indicating reduced consonant/intervocalic duration. Table 2 shows vocalic PVI and intervocalic PVI in all the three age groups.

Table 2: *Mean of vocalic PVI and intervocalic PVI values in different age groups.*

	Girls			Boys			Adults (Savithri et.al, 2006)
	3-4 years	8-9 years	11-12 years	3-4 years	8-9 years	11-12 years	18-25 years
Vocalic PVI	59.39	57.07	60.75	63.16	58.78	59.73	46.95
*(SD)	(11.75)	(4.64)	(6.19)	(13.75)	(4.23)	(5.15)	
Intervocalic PVI	85.22	54.54	53.72	70.43	54.33	43.12	46.18
*(SD)	(5.21)	(8.66)	(8.65)	(6.19)	(9.29)	(6.12)	

*Standard Deviation indicated in parenthesis

In the present study the vocalic PVI and intervocalic PVI in 11-12 year old children approximated adult values (Savithri et. al., 2006). Speech samples like picture description and story narration were used in the present study whereas reading samples was used by Savithri et.al (2006). Though the material used in both the groups was different, they are comparable because both elicited monologues. The results showed that the intervocalic PVI contributed to the classification of rhythm patterns but the vocalic PVI did not. A comparison of vocalic PVI and intervocalic PVI in children obtained in the present study and adult values obtained by Savithri et.al (2006) revealed that intervocalic PVI decreased from 3-4 year to 11-12 year old children to adults. A developmental trend was observed in speech rhythm. The pattern changed from syllable timed in the younger age group to mora-timed in the older group of children which closely approximated the adult rhythm pattern. Figure 5 shows the vocalic PVI and intervocalic PVI in all three groups of children in the present study with that of adults (Savithri et. al, 2006).
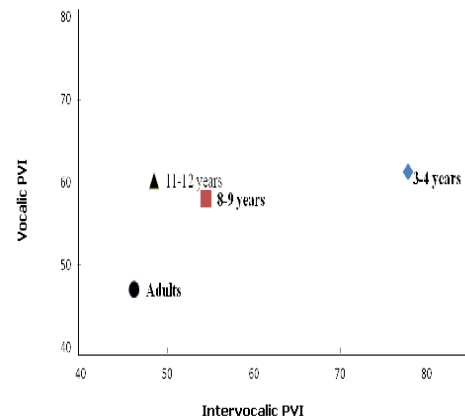

Figure 5: *PVIs in 3-4 year, 8-9 year, and 11-12 year old children and adults speaking Kannada.*

The results also indicated that the vocalic PVI was relatively stable whereas intervocalic PVI decreased with increase in age. Figure 6 shows the PVI values in Kannada and other languages of the world. The PVIs in 3-4 year old Kannada speaking children was closer to British English; those of 8-9 and 11-12 year were closer to German and adults was closer to Rumanian. British English is traditionally classified as

stress-timed and Rumanain is unclassified. However, the basis of such classification in unclear. As evident, there is no support for a strict categorical distinction between languages with high vocalic and intervocalic values and languages with low vocalic and intervocalic PVI values. Rather it appears that languages can be more or less 'stress-timed' (high vocalic PVI and high intervocalic PVI) or 'syllable-timed' (high intervocalic PVI and low vocalic PVI). The investigation of speech rhythm in children from 3-12 years is expected to provide greater details on developmental pattern of rhythm.
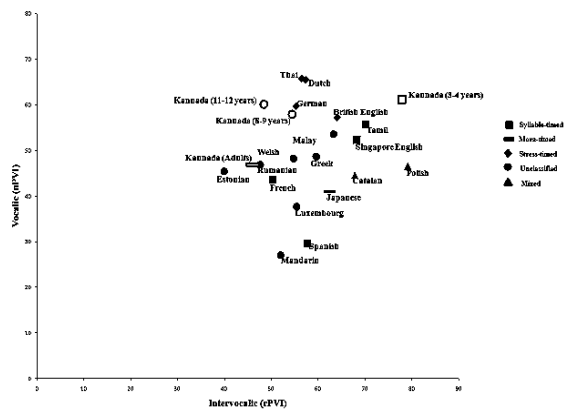

Figure 6: *PVIs in Kannada and other languages.*

Conclusion

The present study investigated speech rhythm in typically developing Kannada speaking children by measuring the vocalic and intervocalic intervals. It was found that 3-4 year old children had syllable-timed rhythm pattern. Rhythm type in 8-9 year and 11-12 year old children was mora timed. The findings of the present study indicate that there is a need to develop data on rhythm to understand the developmental pattern and design better treatment strategies for prosodic errors.

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