Speech Rhythm in Hearing-Impaired Children

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Abstract

Rhythm, a prosodic feature, refers to an event repeated regularly over a period of time. Research on speech rhythm in the last few years has been largely concerned with attempting to search for the acoustic correlates of rhythmic classification. Speech rhythm in pathological cases has not been studied extensively. In this context, the present study investigated speech rhythm in normal and hearing-impaired children using Pairwise Variability Index (PVI) index. The PVI is one measure used to calculate the extent of unit-to-unit variation in speech. Twenty normal hearing and twenty hearing impaired Kannada speaking children in the age range of 5-10 years participated in the study. The subject's spontaneous speech and narrations were audio recorded and stored onto computer. The vocalic and intervocalic durations were measured using Cool Edit Pro software. The results revealed longer vocalic and intervocalic durations in hearing-impaired children in comparison with normals. It is concluded that both the hearing-impaired and normal children have unclassified rhythmic patterns.

Key words: Rhythm, Pair wise variability index, Rhythmic patterns.

Rhythm, a prosodicfeature, refers to an event repeated regularly overa period of time. In stress-timed languages, intervals between stresses or rhythm are said to be near equal, whereas in syllable-timed languages successive syllables are said to be of near-equal length. A third type of rhythm, mora timing, was proposed by Bloch (1950), Han (1962), and Ladefoged (1975) where successive morae are said to be near equal in duration. Mora- timing was exemplified by Japanese. The Pairwise Variability Index (PVI) is a quantitative measure of acoustic correlates of speech rhythm, which calculates the pattering of successive vocalic and intervocalic (or consonantal) intervals showing how one linguistic unit differs from its neighbour (Low, 1998). Grabe & Low (2000) developed normalized Pairwise Variability Index (nPVI) for rhythmic analysis of vocalic durations. The raw Pairwise Variability Index" (rPVI) is used for rhythmic analysis of intervocalic durations. Table 1 summarizes the basic characteristics of each language class regarding relative values of vocalic nPVI and intervocalic rPVI.

Language Class	Languages	Intervocalic rPVI	Vocalic nPVI
Stress-timed	English, Germany	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.

Few investigators have reported rhythm in pathological population. Dankovicova, Gurd, Marshall, Macmohan, Stuart-Smith, Coleman, & Slater (2001) reported that speech of English speaker individual with foreign accent Syndrome and ataxic dysarthria is more syllable-timed than that of normal controls. Using an early forerunner of the PVI, Ackerman & Hertrich (1994) and Kent, Rosenbek, Vorperian, & Weismer (1997) found little evidence of syllable timing for ataxic population. As there is dearth of studies in rhythm for hearing impaired, the present study investigated the rhythm in normal and hearing-impaired children.

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Method

Subjects: The experimental group included 20 hearing impaired Kannada speaking children in the age range of 5-10 years. All subjects had bilateral severe sensori-neural hearing loss, normal oral structures, no other associated psychological or neurological problems, language age of atleast 3 years on REELS and all subjects attended regular speech therapy or normal school. The control group consisted of age, gender and language age matched Kannada speaking 20 normal children.

Material: Pictures developed by Indu (1991), Nagapoornima(1991), Yamini (1991) and Rajendra Swamy (1992) were used to elicit speech. In addition story telling was also used.

Procedure: Subjects were instructed to describe the pictures, narrate the story, which were audio-recorded using MZ-R30 digital Sony recorder and stored onto the computer. Waveform display obtained from Cool Edit Pro software was used to measure vocalic (V) and intervocalic (IV) interval. The vocalic measure (nPVI) refers to the duration of vowel, which was measured as the time duration from the onset of voicing to the offset of voicing for the vowels. Intervocalic measure (rPVI) refers to the duration between two vocalic segments. It was measured as the time duration between the offset of the previous vocalic segment to the onset of subsequent vocalic segment. A program in C language was developed (Vasanthalakshmi, 2005) to compute nPVI and rPVI. The raw Pairwise Variability Index (rPVI) is defined as follows:

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

Where, m is the number of intervals and dk is the duration of the kth interval. The normalized Pairwise Variability Index (nPVI) is defined as follows:

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

Where, m is the number of intervals and dk is the duration of the kth interval.

The duration difference between the first and second, the second and third vocalic segment and so on was averaged to get nPVI. The same procedure was used to obtain averaged intervocalic durations. Pauses between intonation phrases, as well as hesitations, were excluded from the analysis.

Statistical analysis: The mean rPVI and mean nPVI values were calculated for both normal and hearing impaired children. Repeated measure ANOVA was used to obtain significant differences, if any, between groups.

Results and Discussion

Independent t-test indicated a significant difference between groups on rPVI (intervocalic) [t (38) = 2.54, $p<0.05$] and nPVI (vocalic) [t (38) = 2.30, $p<0.05$] values. Both rPVI and nPVI values were higher in hearing-impaired children compared to normal children. Within the normal group, no statistically significant difference was obtained between genders for rPVI [t (18) = 0.217, $p> 0.05$] and nPVI [t (18) = 0.293, $p>0.05$]. Also, within the hearing impaired group, no statistically significant difference was obtained between genders for rPVI [t (18) = 0.365, $p> 0.05$] and nPVI [t (18) = 0.685, $p>0.05$]. Table 2 shows the rPVI and nPVI values of normal and hearing impaired children. Mean and Standard deviation of normal and hearing-impaired children is depicted in figure 1.

Subject	Normals		Hearing-Impaired	
	rPVI	nPVI	rPVI	nPVI
1	13.80	64.16	18.14	71.01
2	14.15	67.15	31.40	73.02
3	12.99	60.66	31.51	62.81
4	16.47	64.04	19.50	58.05
5	16.47	62.37	15.54	79.55
6	17.68	60.90	13.28	77.11
7	15.75	63.21	17.86	83.91
8	18.71	65.83	10.74	57.57
9	17.79	62.08	27.23	76.70
10	13.23	64.85	10.09	70.72
11	19.63	59.26	26.21	61.88
12	13.86	63.55	30.10	78.66
13	15.52	62.30	10.30	60.93
14	16.92	63.60	15.78	58.06
15	17.20	68.27	15.55	59.88
16	12.69	61.85	32.50	58.66
17	15.56	54.81	21.40	61.56
18	21.01	56.99	11.63	62.08
19	14.02	62.94	18.58	63.26
20	10.63	61.17	33.65	67.57
Mean	15.70	62.49	20.54	67.14

Table 2: rPVI and nPVI values in normal and hearing impaired children.

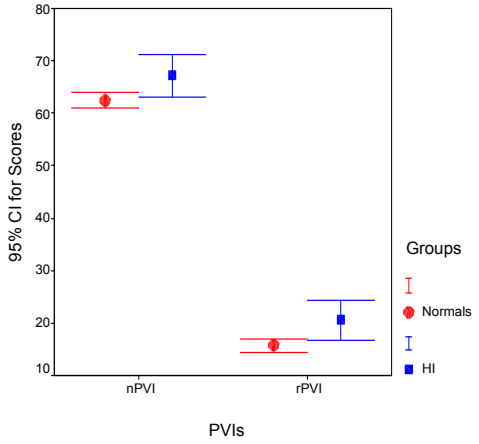

Figure 1: Mean and standard deviation in normals and hearing-impaired.

The results indicated high nPVI and low rPVI values in both groups and therefore the rhythmic pattern found in hearing impaired and normal children remains unclassified and cannot be placed in any of the rhythmic classes (stress-timed, syllable-timed, mora-timed).

The results indicated several points of interest. Firstly, the results indicated that the rhythmic pattern found in hearing impaired and normal children remained unclassified and cannot be placed in any of the rhythmic classes (stress-timed, syllable-timed, mora-timed) since the nPVI values were found to be higher than values of rPVI in both groups which implies that the usage of vowels in their speech was more; subjects are still in the acquisition stage of rhythm.

Comparison of the PVI values in adults and children showed that nPVI values were higher in children than the adults whereas rPVI values were higher in adults when compared to children. This may be due to the reason that the speech task in children is unpredictable unlike the reading task by adults and hence would have an influence on differences in PVI values. Figure 2 shows the PVIs in children and adults. adults.

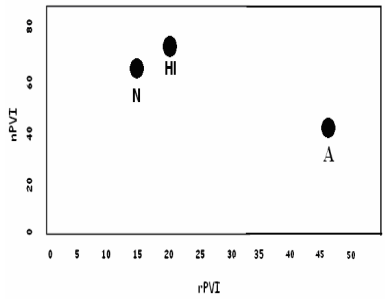

Figure 2: Mean rPVI and nPVI values for normal, hearing-impaired children and adults.

Also, the types of syllable used in children and adults were different. The percentage use of different types of syllable structures by normal and hearing impaired children and adults (Savithri et.al.2005) was calculated and tabulated. Results indicated that the type of syllable structure used by three groups differed. Children used V, CV and CCV syllables, and adults, in addition, used CCV syllables. The percentage use of V and CV syllables was more in HI children compared to normal children. Table 3 shows the percentage of various syllables used in three groups of subjects.

Groups	V	CV	CCV	CCCV
Normal children	21.15	61.62	17.21	0
HI Children	23.27	68.82	7.95	0
Adults	6.86	80.63	12.38	0.11

Table 3: Percentage use of different syllable structures.

The usage of more vocalic syllables and less CV syllables in children compared to adults might be a reason for low rPVI.

Conclusions

Rhythm has been defined as an effect involving the isochronous recurrence of some type of speech unit. Basically languages have

been organized under three types of rhythm i.e. stress-timed, syllable-timed and mora-timed. The present study investigated the rhythm in normal and hearing-impaired children. Pair-wise Variability Indices (PVI's) were used to find the vocalic and intervocalic durations. The vocalic measure (nPVI) refers to the duration of vowel, which was measured as the time duration from the onset of voicing to the offset of voicing for the vowels. Intervocalic measure (rPVI) refers to the duration between two vocalic segments. The results showed that the speech rhythm in normal and hearing impaired children remained unclassified. No gender differences were observed in any group. A high nPVI value and low rPVI value was obtained in both groups. Savithri, Jayaram, Kedarnath, & Goswami (2005) classified Kannada as a mora- timed language in normal adults. But, the results of the present study are not in consonance with the earlier study, which indicates that the acquisition of adult-like rhythm is not yet achieved in the children of the present study. The syllabic structure used by children also differed from that of the adults. Therefore the results of the present study reveals that the syllabic structure used by children is simpler than the adults and children are in acquisition stage of rhythmic patterns. Thus, it implies that there is a need to develop the normative data for the age at which children acquire the adult like rhythmic pattern.

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