Journal of Phonetics and Audiology

Prabhu et al., J Phonet Audiol 2016, 2:1
http://dx.doi.org/10.4172/jpay.1000116

Research Article Open Access

The Factors Affecting the Perception of Malayalam Time Compressed Speech in Children and Young Adults

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Received date: January 25, 2016; **Accepted date:** February 27, 2016; **Published date:** March 15, 2016

Abstract

Objective: It was attempted to determine whether the speech identification scores (SIS) vary across compression ratios for Malayalam time compressed speech and monosyllables in children and young adults. The study attempted to assess stimulus and subject factors affecting the perception of Malayalam time compressed speech and monosyllables in children and young adults.

Method: PB words and monosyllables were time compressed at compression ratios of 50%, 60%, 70% and 80%. The speech identification scores were determined for each compression ratio for both stimuli in children and young adults.

Results: The speech identification scores (SIS) decreased with increase in compression ratio and there was no gender effect. The scores were poorer for children compared to young adults. The SIS was better for monosyllables at higher compression ratios.

Conclusion: The study recommends using 50% compression ratio while testing clinical population in children and young adults. Thus, understanding the factors affecting Malayalam time compressed speech helps in better utilization of the test in clinical population.

Keywords: Malayalam; Monosyllables; PB words; Time compressed speech; Compression ratio; Gender; Age

Introduction

Auditory processing requires acquisition of auditory processes namely sound localization and lateralization; auditory discrimination; auditory pattern recognition; audition in temporal aspects; auditory performance in competing acoustic signals; and auditory performance with degraded acoustic signals [1-3]. If a person has abnormality in any one or more of these processes he/she is referred to as having (Central) auditory processing disorder [(C) APD] [1]. This abnormality is not because of the problem in language, cognitive or other factors [1]. Central auditory processing disorders [(C) APD] are usually assessed using a battery of tests. Baran [4] classified the test battery for (C) APD into five categories namely dichotic tests, auditory temporal processing and patterning tests, binaural interaction tests, monoaural low-redundancy tests, and electrophysiologic tests. Auditory closure abilities are usually assessed using monoaural low redundancy tests. One of the common monoaural low redundancy test is the time compressed speech test [5].

Time-compressed speech reduces the extrinsic redundancy of the speech material as the rate of speech is altered without causing distortion of intensity and frequency of speech [6]. The listeners with normal intrinsic redundancy will use their auditory closure skills to fill the missing information in the time compressed speech. However, individuals with (C) APD with reduced intrinsic redundancy exhibit poor performance suggesting auditory closure deficits [6]. The extent of auditory closure deficits can be determined by varying rate of time compression [3]. The time compressed speech material is typically used for assessment of auditory processing disorders or in individuals with neurological deficits [7]. Time-compressed speech test is also efficient in understanding the auditory processing in aging population [8]. It is also reported that training of time-compressed speech enhances the ability to recognize speech even with compression and degradation of speech signal [9].

Considering all these major applications of time compressed speech, it is essential to develop and assess factors affecting time compressed speech in all languages. There are only few Indian studies which assesses stimulus and subject factors affecting time compressed speech [10-13].

However, there is very limited literature on time compressed speech in Malayalam language. It is well established that as degree of time compression (compression ratio) increases the speech perception scores decreases [14,15]. It is reported that the scores reduce gradually from 0% to 60% and more difficulty is experienced at 70% time compression and above [16]. There are reports which suggest that speech perception varies with the type of stimuli used for different degrees of time compression [5]. In addition, the speech identification scores for time compressed speech also varies across age [14] and doesn't vary across gender [13]. However, there are no studies which assess the effect of age, gender, compression ratio and type of stimuli using Malayalam time compressed speech. Malayalam is spoken by a large group of population across the world and it is essential to develop normative scores for Malayalam time compressed speech test. This

Citation: Prabhu P, Rasheed MA, Dinesh T (2016) The Factors Affecting the Perception of Malayalam Time Compressed Speech in Children and Young Adults. J Phonet Audiol 2: 1000114. doi:10.4172/jpay.1000116

would help in evaluation and management of Malayalam speaking clinical population. Thus, in the present study it was attempted to determine whether the speech identification scores (SIS) vary across time compressed phonemically balanced (PB) words and monosyllables for different compression ratios in children and young adults. The study would be helpful in determining the appropriate compression ratio to be used in clinical population. In addition, it would also be useful in determining the subject and stimulus factors which might affect Malayalam time compressed speech test. The specific objectives of the study were to determine and compare SIS for time compressed PB words in Malayalam and monosyllables at compression ratios of 50%, 60%, 70% and 80% in children and young adults. In addition, it was also attempted to determine if there is any gender effect on perception of time compressed speech for PB words and monosyllables.

Method

Participants

A total of eighty normal hearing individuals with 40 children (20 males and 20 females) in the age range of 7-10 years and 40 young adults (20 males and 20 females) in the age range of 18-21 years participated in the study with no otological history. All the participants had normal middle ear functioning. None of the participants reported previous history of long/short term exposure to high level noise, usage of ototoxic drugs, or otological/neurological diseases. All the participants obtained normal speech perception in noise (SPIN) scores. An informed consent was taken from all the participants of the study. All tests were carried out in sound treated audiometric rooms with permissible noise levels standards of ANSI S3.1-1999 (R 2013).

Procedure

Air conduction (AC) and bone conduction (BC) thresholds were estimated using Modified Hughson and Westlake procedure [17]. AC thresholds were obtained for pure tones from 250 Hz to 8 kHz and BC thresholds from 250 Hz to 4 kHz in octave frequencies. Speech identification scores were obtained for phonemically balanced words in Malayalam by Mathew [18]. Immittance evaluation using tympanometry and acoustic reflex threshold testing was done with 226-Hz probe tone and acoustic reflexes for 500, 1000, 2000 and 4000 Hz (Ipsilateral and Contralateral) in a calibrated middle ear analyzer (GSI Tympstar V 2.0). All the participants had normal tympanogram with reflexes present in both ears. Speech Perception in Noise (SPIN) was administered on all the participants at 0 dB signal to noise ratio.

Phonemically balanced word list in Malayalam and monosyllables were subjected for time compression. The recorded stimuli were subjected to normalization such that all the words had same intensity. 1 kHz calibration tone was recorded prior to the lists to monitor the VU meter. Four lists of PB words and 2 lists of monosyllables were randomized using random tables to make eight lists. PB word list and monosyllable word list were time compressed by shortening them digitally using Pitch synchronous overlap and add (PSOLA) method [19] using PRAAT software. PB words and monosyllables were time compressed into compression ratios of 50%, 60%, 70% and 80%. The stimuli were routed through a computer to the CD/Tape input of Piano Inventis diagnostic audiometer through TDH-50 headphones with MX-41/AR cushions. The presentation level of the test material was at 40 dB SL (re: Speech Recognition Threshold). The speech identification scores were determined for each compression ratio for both stimuli. The participants were instructed to give a written response. The participants were also informed to guess the speech items if they were not very clear. 50% of participants were tested in right ear first and the remaining 50% participants were tested in left ear to avoid ear effect. The stimuli presentation was randomized for all the lists to avoid practice and order effect. The correct responses were calculated for both stimuli for all the different ratios and converted to percentage of scores.

Ethical considerations

In the present study, all the testing procedures done were using non-invasive technique adhering to conditions of ethical approval committee of the Institute and complied with the Declaration of Helsinki. All the test procedures were explained to the participant before testing and an informed consent was taken from all the participants.

Results

The results of the study showed that for PB words and monosyllables, SIS was around 85-90% at 50% compression ratio in both the groups. The speech identification scores (SIS) decreased with increase in compression ratio. The scores obtained for PB words by both the groups across different compression ratios are shown in figure 1. The scores obtained for monosyllables by both the groups across different compression ratios are shown in figure 2. Paired Samples t-test also showed that the scores were significantly higher ($p < 0.01$) for young adults compared to children for all the compression ratios in both the groups.

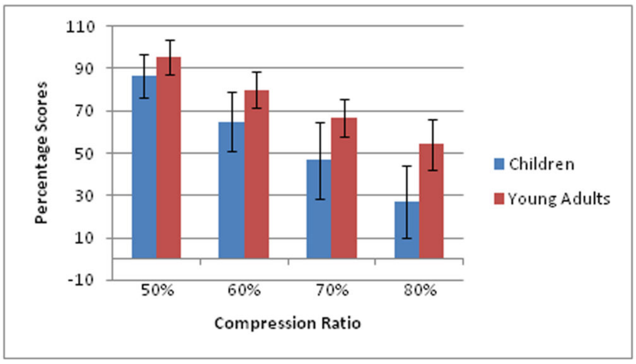

Figure 1: Mean and SD of scores obtained for time compressed PB at different compression ratios in children and young adults.

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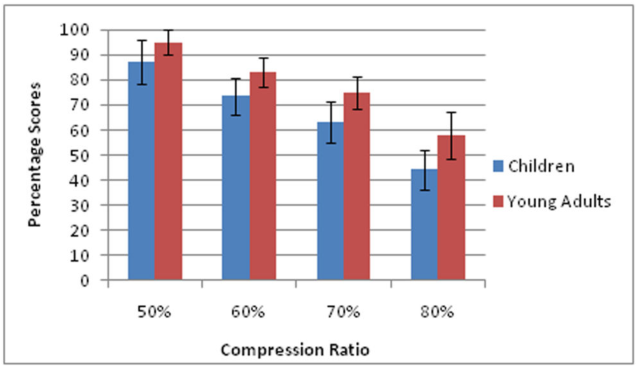

Figure 2: Mean and SD of scores obtained for time compressed monosyllables at different compression ratios in children and young adults.

Paired sample t-tests showed that scores were significantly higher (p < 0.001) for monosyllables compared to PB words at 70% and 80% compression ratios. The difference in means between time compressed monosyllables and PB words across compression ratio was calculated for both groups and the results are shown in figure 3.

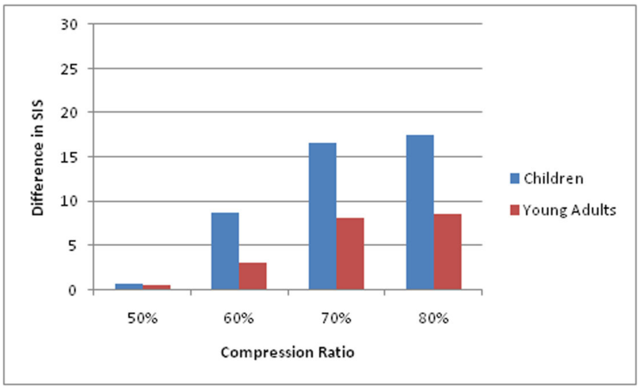

Figure 3: Difference in speech identification scores between monosyllables and PB words for different compression ratios in children and young adults.

Mixed ANOVAs were done considering scores across compression ratio as within subject factor and gender as between subject factor for children and young adults separately. The result showed significant main effect of compression ratio for both PB words and monosyllables in both groups. Bonferroni's multiple comparisons suggested that there was significant difference (p < 0.001) across all the compression ratios for both stimuli in both groups. There was no significant main effect (p>0.05) of gender and interaction of gender and compression ratio. The results of Mixed ANOVA for young adults are shown in table 1 and for children are shown in table 2.

can be used in clinical population as SIS was high (around 85-90%) and had lower standard deviation at 50% ratio for both monosyllables and PB words. Similar results were obtained in other studies on time compressed speech in different languages [14,16]. Malayalam is spoken by more than 38 million people across the world and the test provides valuable

S. No	Compression Ratio	Effects	F value and degrees of freedom	Significance value
1	PB Words	Main effect of Compression Ratio	F (3,234) = 636.12	p <0.05*
		Main effect of Gender	F (1,78) = 0.3	p >0.05
		Interaction Effect	F (3,234) = 1.028	p >0.05
2	Monosyllables	Main effect of Compression Ratio	F (3,234) = 644.34	p <0.05*
		Main effect of Gender	F (1,78) = 0.297	p >0.05
		Interaction Effect	F (3,234) = 1.356	p >0.05

*Significant Difference – Bonferroni Multiple comparison – Significant difference across all compression Ratios across the entire compression ratio tested.

Table 1: Results of Mixed ANOVAs for young adults comparing PB words and monosyllables.

S. No	Compression Ratio	Effects	F value and degrees of freedom	Significance value
1	PB Words	Main effect of Compression Ratio	F (3,234) = 544.12	p <0.05*
		Main effect of Gender	F (1,78) = 0.23	p >0.05
		Interaction Effect	F (3,234) = 1.428	p >0.05
2	Monosyllables	Main effect of Compression Ratio	F (3,234) = 624.34	p <0.05*
		Main effect of Gender	F (1,78) = 0.37	p >0.05
		Interaction Effect	F (3,234) = 1.26	p >0.05

*Significant Difference – Bonferroni Multiple comparison – Significant difference across all compression Ratios across the entire compression ratio tested.

Table 2: Results of Mixed ANOVAs for children comparing PB words and monosyllables.

Discussion

The result of the study shows a reduction in speech identification scores with increase in compression ratio which is in consensus with previous studies on time compressed speech [14,15,20,21]. The scores were highest for lower compression ratios for both the type of stimuli. This suggests that under lower compression ratios, the participants were able to use auditory closure abilities to guess the items correctly

[20-23]. The compression ratio of 50% can be used in clinical population as SIS was high (around 85-90%) and had lower standard deviation at 50% ratio for both monosyllables and PB words. Similar results were obtained in other studies on time compressed speech in different languages [14,16]. Malayalam is spoken by more than 38 million people across the world and the test provides valuable normative data for comparison while evaluating clinical population. Thus, it is essential to develop language specific time compressed speech tests for appropriate assessment and management of clinical population.

The results of the present study also showed no effect of gender on time compressed speech. Lau [21] also reported that performance on time compressed speech didn't vary across gender for Cantonese time compressed speech test. Prabhu et al. [13] also reported no effect of gender on perception of time compressed PB words and monosyllables in adult Kannada speakers. Bhargavi et al. [12], Sujitha [11] and Kumar [10] also reported that there was no difference in terms of gender for different compression ratios in children between 7-12 years on tests of time compressed speech in Indian languages. Thus, the results of the present study are in agreement with previous reported studies which suggest that there exists no significant gender effect on time compressed speech for different compression ratios [12,20,21]. This result suggests that there is no need to have separate normative values for males and females for time compressed speech test with PB words and monosyllables.

The study also showed that children have relatively lower SIS compared to young adults. The result obtained in the present study is similar to other studies on time compressed speech [3,21,24,25]. This highlights the importance of developing separate normative scores for children and young adults. The result also suggests that auditory closure abilities mature with increase in age [14,21,24]. SIS was better for monosyllables compared to PB words at higher compression ratios. The speech identification scores for time compressed speech were expected to be better for PB words compared to monosyllables considering higher redundancy for PB words. However, an inverse result was obtained in our study where scores were better for monosyllables compared to PB words at all compression ratios and the difference was more at higher compression ratios. The monosyllables used in the study lacked consonant clusters and all the syllables were non-sense consonant-vowel syllables and the PB words did have consonant clusters. As observed, after the time compression, the consonant clusters were absent reducing the important temporal cues which may have led to higher mistakes for PB words. This effect of loss of temporal cues on SIS is reported to be more as the compression ratio increases. Rabelo and Schochat [5] also reported that scores were better for monosyllables compared to disyllables for Brazilian time compressed speech. They also attributed the difference to loss of consonant clusters in disyllables for poorer speech identification scores. Similar result was also obtained for Kannada time compressed speech test by Prabhu et al. [20]. The present study provides separate clinical normative data for children and young adults at different compression ratios. The study needs to be further carried out on clinical population to determine its utility as it would help in identifying Malayalam speaking individuals with (C) APD. In addition, the test may also be administered on geriatric population to study the auditory closure abilities.

Conclusions

The study provides normative data on stimulus and subject factors affecting the perception of Malayalam time compressed speech in children and young adults. The speech identification scores (SIS) decreased with increase in compression ratio and there was no gender effect. The scores were poorer for children compared to young adults. The SIS was better for monosyllables at higher compression ratios. The study recommends using 50% compression ratio while testing clinical population in children and young adults. The study also recommends the use of monosyllables while using higher compression ratios. Thus, understanding the factors affecting Malayalam time compressed speech helps in better utilization of the test in clinical population.

Conflict of interest statement

The author reports no conflicts of interest. The author alone is responsible for the content and writing of the paper.

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