Cross Language Perception of Voicing in Children With Hearing Impairment

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Abstract

The present study was designed to evaluate the discrimination of stop consonant voicing in children with hearing impairment who were exposed to different regional languages (Kannada and Malayalam). Eighteen children with hearing impairment (10 Kannada speaking children and 8 Malayalam speaking children) with moderate to moderately severe degree of sensorineural hearing loss were evaluated. The results indicated that perception of voicing was significantly better for the Kannada speaking children with hearing impairment compared to the Malayalam speaking children with hearing impairment. This was observed irrespective of the place of articulation where the stop occurred (bilabial, dental, retroflex and palatal), the vowel along with which it was produced (\a\, \i\ and \u\) and the position (initial and medial).

Introduction

The voicing of consonants has been found to be an important distinction in speech communication, as indicated by statistics of phonological contrasts (Carterette and Jones, 1974). Children with hearing impairment have been noted to have difficulty in both discrimination and production of the voiced-voiceless speech sound distinction (Bennett & Ling, 1973). They often produce voiced consonants that are voiceless, and vice versa (Calvert, 1961; Preston, Yeni-Komshian and Stark, 1967). This confusion has been noted to frequently occur when a voiceless sound is surrounded by strongly voiced sounds (Levitt, 1971). This has been considered to be related to the difficulty children with hearing impairment have in discriminating the presence or absence of voicing cues.

Generally it has been observed that most of the listeners with hearing impairment use the same voiced and voiceless cues as used by the normal hearing listeners, although some of them may be unable to make full use of these cues (Pickett and Revoile, 1983). Listeners with hearing impairment were found to be less sensitive to the vowel-onset transition cues than the normal hearing listeners (Lisker and Abramson, 1972). The other cues used by them to differentiate voice-voiceless contrasts have been noted to different to what is used by normal hearing individuals.

Children with moderate-to-severe sensorineural hearing impairment are known to identify the voicing characteristics of naturally produced stop consonants accurately (Byers, 1973; Erber, 1972). These experiments establish that children with hearing impairment can readily identify signals which differ greatly in the acoustic cues that signal voicing.

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A common outcome of experiments on the identification of stop consonants by children with moderate and severe hearing losses is that the children make relatively few errors when identifying the voicing feature of the consonants, but make relatively more errors when identifying the place feature (Byers, 1973; Erber, 1972).

Studies carried out in India have reported that there exist differences in voicing contrasts in various Indian languages. Malayalam is a semi syllabic phoneme-rich language of the Dravidian language family spoken in the southern state of Kerala. Kannada belongs to the same family spoken in another southern state of Karnataka. In Malayalam and Kannada, voiced plosives are characterized by lead VOT and unvoiced plosives by lag VOT. Voiced plosives in Malayalam have longer lead VOT and shorter lag VOT compared to those in Kannada (Savithri, Sreedevi and Santosh, 2001). All these can be attributed to the differences in the phonological structure of each of these languages.

It has been reported by Ramakrishna, Nair, Chiplukar, Ramachandran and Subramanian (1962) that Malayalam has 21 stop consonants, of which 10 are grouped into five pairs each with voiced and voiceless counterparts. The alveolar stop has no voiced counterpart. It has only a voiced allophone which occurs after homorganic nasal. In Malayalam, voiced plosives have been found to be characterized by lag VOT. Voiced plosives in Malayalam have longer lead VOT and shorter lag VOT. However, no significant difference between the transition duration of voiced and unvoiced plosives have been reported. VOT has been found to be used more than transitions to contrast voicing in word-initial position in Malayalam (Savithri et al., 2001).

Studies of phonemes occurrence in conversation have indicated that the voicing feature is a very important phonological distinction (Mines, Hanson and Shoup, 1978). There is a need to evaluate the perception of voicing of stops in children with hearing impairment exposed to different regional languages. Voicing is produced differently in different languages. In Malayalam, voiceless stops have been observed to be produced with a trailing voicing in the medial position (Geethakumary, 2002). However, the voicing distinction is perceived when produced by a native as well as non-native speaker of the language. There is a need to know whether children with hearing impairment, with different exposure to voicing, are able to perceive them similar to their normal hearing counterparts. This study will help in knowing how voicing features of stops are perceived by Malayalam and Kannada speaking children with hearing impairment.

Besides knowing how children from each of the above language groups perceive voicing contrasts, there is also a need to compare the way they differ in the perception the contrasts. Such information will be helpful in developing materials to teach voicing features in children with hearing impairment, which in turn would help them to perceive the contrasts.

The aim of the present study was to see if stop voicing can be perceived equally well by two groups of children with hearing impairment, belonging to two different

languages groups. Thus, the study aimed at evaluating the voicing perception in children with hearing impairment exposed either to Kannada or Malayalam. The study also aimed at studying the effect of place of articulation, vowel environment and position of stop, on voicing perception in these two groups.

Method

Voice-voiceless discrimination in four places of articulation (bilabial, dental, retroflex and palatal), in two positions (initial and medial) and with three vowel environments (\a\, \i\, \u\) were evaluated. This was done on children with hearing impairment, exposed either to Kannada or Malayalam.

Participants:

Ten Kannada and eight Malayalam speaking children in the age range of 6 years to 13 years with moderate to severe degree of sensorineural hearing loss were studied. They all used BTE hearing aids for at least 4 years, and their aided thresholds were within the speech spectrum at least up to 2 kHz. It was confirmed that they had not undergone prior training specifically to learn voicing contrasts. They were able to communicate in sentences and had adequate speech and language skills. They had average intellectual capacity and no neurological problems or additional physical disabilities.

Instrumentation

A Pentium IV computer with Adobe Audition 2.0 software was used for the presentation of the stimuli. A calibrated two channel diagnostic audiometer, Orbiter 922 was used for the selection of participant and for the presentation of the stimuli. An immittance meter GSI Tympstar provided information regarding the absence of any middle ear problem. A Pentium IV computer was used for presenting the speech stimuli for the discrimination activity.

Test environment:

All the tests were carried out in an air conditioned sound treated two-roomed condition. The ambient noise levels were within permissible limits (ANSI S3.1, 1991). The recording of the material for the study was also done in a sound treated room.

Procedure:

Material development:

Nonsense consonants-vowel (CV) and consonant-vowel-consonant (CVC) syllables were used as test stimuli. Stops (\p\, \t\,\th\, \k\, \b\, \d\, \dh\, \g\) which are common in Kannada and Malayalam were selected. Each of these consonants was combined with the vowels \a\, \i\ and \u\. Thus, a total of 72 stimuli were recorded. The stimuli were randomized to form two sets. The consonants were used in the initial and

medial positions. The final position was not used since consonants are not used in this position in Kannada.

The speech stimuli were recorded by a male speaker whose mother tongue was Kannada. A Kannada talker was used since native speakers of Malayalam tend to produce voiceless stops in the medial position with a trailing voicing (Geethakumary, 2002). The recording was done on a Pentium IV computer using the Adobe Audition Software at a sampling frequency of 16 kHz. A unidirectional microphone was used for the recording, and it was kept at a distance of 10 cm from the speaker's mouth. The recorded material was normalized using the Adobe Audition software so that all the speech stimuli were of same intensity. A 1 kHz calibrated tone was recorded prior to the speech stimuli. An interstimulus interval of 3 sec was maintained for obtaining the responses from the participants. The recorded material was written on a CD. The recorded material was heard by ten native adult listeners of Kannada to get a goodness rating of the recorded material. The stimuli were considered acceptable only if 90% of these adults, having normal hearing, were able to identify the stimuli correctly.

Procedures for participant's selection:

A preliminary pure-tone audiometry was done to determine the hearing threshold of the participants using a calibrated Madsen OB-922 diagnostics clinical audiometer. Air conduction thresholds were obtained between 250 Hz and 8 kHz and bone-conduction threshold were obtained between 250 Hz and 4 kHz. Screening tympanometry and reflex threshold testing were done using a calibrated GSI-TS impedance audiometer to rule out the presence of any middle ear pathology.

Procedure for speech discrimination testing:

The developed materials were presented using a Pentium IV computer. The output from the computer was routed to the tape input of the audiometer (OB-922). Prior to the presentation of the stimuli, a 1 kHz calibrated tone was presented to set the VU meter deflection of audiometer to '0'. Participants heard the stimuli through a TDH-39 headphone. The stimuli were presented in pairs and the child had to indicate whether the pairs were same or different. This was done by asking each child to point to pairs of drawings, one pair having similar pictures and one pair having dissimilar pictures. Prior to the actual testing, each child was trained using practice items. Instructions were given to the children orally in their respective language. It was ensured that the children followed the instruction and pointed to the correct picture-pair, on hearing the stimuli. Following the practice trial, the children were tested using the 72 test items. All stimuli were randomized to avoid any order effect. For children who showed any sign of fatigue, breaks were given. Social as well as token reinforcement were given for correct responses. A random schedule of reinforcement was used. Test-retest reliability was obtained on all of the Malayalam speaking children and 60% of the Kannada speaking children. The retest was done using a different list containing the same test materials that

were randomized. The test stimuli were administered to the better ear of each child at the most comfortable level (MCL) at 30 dB SL.

The responses of the children were noted by the experimenter. A correct response was given a score of '1' and a wrong response was given a score of '0'. The data thus collected were subjected to statistical analyses using the Statistical Packages for Social Sciences (SPSS) software version 15.

Results and Discussion

The data obtained from the eighteen children with hearing impairment (10 Kannada speaking & 8 Malayalam speaking) were analyzed using descriptive statistics, mixed ANOVA, repeated measure ANOVA and independent 't' test. Details of results are *further discussed.*

Comparison of voicing within and between language groups:

The mean and standard deviation for score obtained for each language group was computed. This information is provided in Figure 1. These scores represented the responses obtained to all 72 stimuli by each language group.

From Figure 1 it is evident that the Kannada speaking children with hearing impairment could correctly discriminate the 72 stimuli 81% of the time. However, the matched Malayalam speaking children with hearing impairment could discriminate the same tokens only 65% of the time. Though the Kannada speaking children obtained a higher mean value, the variability in their score was also higher.

In order to check whether the discrimination scores differed significantly between the two language groups, an independent 't' test was administered. The results revealed that the scores between the two language groups were significantly different with respect to the total scores [t (16) = 3.899, p < 0.001]. The perception of voicing was significantly better for the Kannada speaking children with hearing impairment compared to the Malayalam speaking children with hearing impairment.

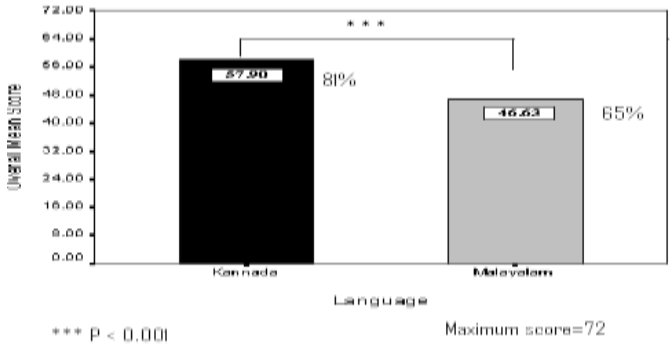

Figure 1: Mean total raw score for the Kannada and Malayalam speaking groups

Effect of place of articulation on discrimination of voicing

Discrimination of voicing as a function of place of articulation was measured separately for the Kannada and Malayalam speaking children with hearing impairment. This was done to see whether the ability to discriminate voicing was influenced by the place of articulation in each of the language groups. The mean scores for voicing as a measure for place of articulation was more for the Kannada speaking group. The mean and SD obtained for the two groups is shown in Table 1.

Table 1: *Mean and standard deviation of voicing as a measure for place of articulation*

Place of articulation	**Language**				**Possible maximum score**
	Kannada		**Malayalam**		
	Mean#	**SD**	**Mean#**	**SD**	
\p-b\	14.10	2.69	11.13	1.25	18
\t-d\	15.10	1.67	11.63	1.85	18
\k-g\	15.10	1.92	12.00	2.00	18
\th-dh\	13.60	2.46	11.88	1.36	18

Maximum scores = 18

In order to determine whether there was a significant difference within and between the two groups, ANOVA was done. The ANOVA (4 place of articulation x 2 groups) revealed there was no significant main effect for the different place of articulation [$F (3, 48) = 1.738$, $p > 0.05$)] and also there was no significant interaction effect found between place of articulation and language [$F (3, 48) = 1.183$, $p > 0.05$). However, it was once again observed that a significant difference existed between the two language groups, Kannada and Malayalam [$F (1, 16) = 15.199$, $p< 0.01$)].

To check the influence of place of articulation on the discrimination of voicing in each language groups, repeated measure ANOVA was performed. The results revealed that there was no significant difference between the place of articulation in the Kannada speaking children with hearing impairment [$F (3, 27) = 3.172$, $p> 0.05$]. Likewise, there was no significant difference between place of articulation in the Malayalam speaking children with hearing impairment [$F (3, 21) =0.448$, $p> 0.05$]. Thus, the place of articulation did not influence the way the two groups perceive voiced \ voiceless stops.

The effect of place of articulation on the discrimination of voicing between the Kannada and Malayalam speaking children was determined using a mixed ANOVA. The mixed ANOVA brought to light that there did exist a significant main effect of place of articulation between the two language groups [$F (1, 16) = 15.199$, $p< 0.01$)]. To get a better understanding of the effect of place of articulation on voicing discrimination between the two language groups, separate independent 't' tests were carried out. The results of the 't' tests revealed a significant difference between the two language groups

regarding the way they perceive voicing of bilabials ($p < 0.05$), palatals ($p < 0.01$) and velars ($p < 0.01$). However, there was no significant difference between the two groups regarding the way they perceived voicing of dental stops ($p > 0.05$). This is depicted in Table 2 and Figure 2.

Table 2: Significance of difference between mean voicing perception scores between the two language groups, for each place of articulation.

Stimuli	**Language groups**	**Mean scores #**	**'t' value**
\p-b\	Kannada	14.10	2.88*
	Malayalam	11.13	
\th-dh\	Kannada	13.60	1.77
	Malayalam	11.88	
\t-d\	Kannada	15.10	4.20**
	Malayalam	11.63	
\k-g\	Kannada	15.10	3.35**
	Malayalam	12.00	

*Significant at 0.05 level.
**Significant at 0.01 level.
Maximum scores = 18

The results also revealed that the mean scores for all the four place of articulation were higher for the Kannada speaking children with hearing impairment compared to the Malayalam speaking children with hearing impairment. Though the difference was not significantly higher for the dentals, the Kannada group continued to perform better than the Malayalam group. The performance of the Kannada group was slightly lower for this place of articulation compared to their perception of other places of articulation. However, the Malayalam groups performed similarly for all four places of articulation, resulting in no significance of difference for the \th-dh\ contrast.

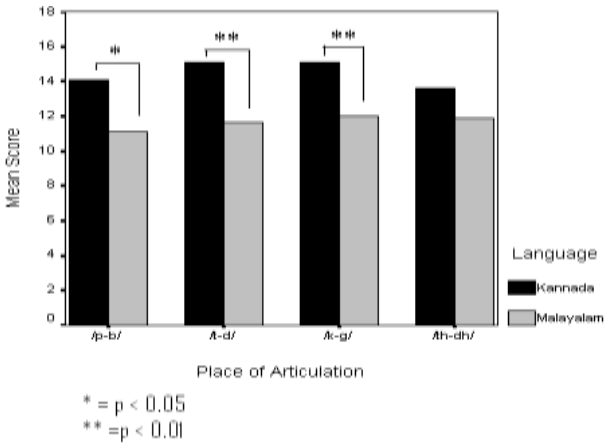

Figure 2: Mean voicing perception scores between the language groups at four places of articulation

Effect of vowels on the perception of voicing

Voicing perception as a function of vowel environments (\a\, \i\, \u\) was measured for both Kannada as well as Malayalam speaking children with hearing impairment. From Table 3 it is evident that irrespective of the vowel environment, the scores were better for the Kannada speaking children with hearing impairment compared to the Malayalam speaking children with hearing impairment. However, the SD for the two groups was approximately the same.

Table 3: Mean and standard deviation of voicing perception in different vowel environments

Vowel environment	**Language**			
	Kannada		**Malayalam**	
	Mean#	**SD**	**Mean#**	**SD**
\a\	19.50	2.80	16.00	2.45
\i\	19.20	2.58	14.50	1.78
\u\	19.20	2.58	16.13	2.11

Maximum scores = 24

Mixed ANOVA (Repeated measure of ANOVA with language as independent factor) was carried out to check the significance differences of mean perception of voicing in different vowel contexts. The 3 vowel environment X 2 group ANOVA revealed that there was no significant difference in voicing perception with different vowel combination [$F(2, 32) = 1.623$, $p > 0.05$)]. Also, there was no significant interaction effect found between different vowel combination and language [$F(2, 32) = 1.170$, $p > 0.05$), but the results revealed a significant difference between the two languages, Kannada and Malayalam [$F(1, 16) = 15.199$, $p < 0.01$)].

Separate one-way ANOVAs were performed on the Kannada speaking group and the Malayalam speaking group to determine the influence of vowels within each language group. These revealed that there was no significant difference between different vowel combination in the Kannada speaking children with hearing impairment [F (2, 18) = 0.310, p > 0.05]. Similarly, there was no significant difference between voicing perception with different vowel combination in the Malayalam speaking children with hearing impairment [F (2, 14) =1.329, p > 0.05]. From this it can be inferred that voicing perception was not influenced by the vowel context in which it occurred.

The influence of vowels on voicing perception between the Kannada and Malayalam speaking children was evaluated using a mixed ANOVA. A significant effect of the vowel context on voicing perception between the two language groups was obtained [F (1, 16) = 15.199, p < 0.01)]. To determine the effect of specific vowels across the two groups, separate independent sample 't' tests were carried out. The results from the 't' test revealed a significant difference in the way the two groups perceived voicing in all three vowel environments (Table 4).

Table 4: Significance of difference between mean voicing perception scores between the two language groups, for each vowel environment

Types of vowel environment	**Language groups**	**Mean scores#**	**'t' value**
\a\	Kannada	19.50	2.783*
	Malayalam	16.00	
\i\	Kannada	19.20	4.388***
	Malayalam	14.50	
\u\	Kannada	19.20	2.726*
	Malayalam	16.13	

#Maximum scores = 24 *Significant at 0.05 level of significance

***Significant at 0.001 level of significance

The results also revealed that the mean scores for all the three vowel environment were higher for the Kannada speaking children with hearing impairment compared to the Malayalam speaking children with hearing impairment (Figure 3).

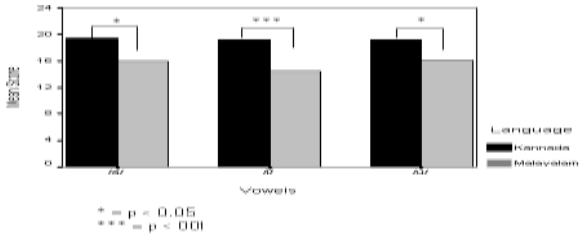

Figure 3*:* Mean voicing perception scores between the language groups at three vowel environment

Effect of position of stop on voicing perception within and between language groups

Perception of voicing as a function of position of stop consonants (initial and medial position) was assessed separately for the Kannada and Malayalam speaking children with hearing impairment. The data was analyzed to see whether the position of stop consonant effected the voicing perception in each of the language groups. Within each language group, it can be noted from Table 5 that the mean values were very similar for stops occurring in the initial and medial position. However, the mean scores as well as SD values were higher for the Kannada group than for the Malayalam group.

A paired sample 't' test was performed to assess the effect of initial and medial position of stop consonants on voicing perception within each language group. The analysis revealed that there was no significant difference ($p > 0.05$) between the scores obtained in the two positions in both language groups.

Table 5: Significance of difference between in scores obtained in the initial and medial position within each language group.

Groups	Position	Mean [#]	SD	't' value
Kannada	Initial	29.0	4.4	0.63
	Medial	29.6	3.9	
Malayalam	Initial	23.0	1.7	0.07
	Medial	23.06	2.8	

[#] Maximum score = 36

A paired sample 't' test was also performed to assess the effect of position of stop consonants on voicing perception between the Kannada and Malayalam groups. The results of paired sample 't' test revealed there was a highly significant difference in the mean scores for each position between the language groups (Table 6). It can be noted from the table that the Kannada speaking children had higher scores in both the initial and medial position when compared to the Malayalam speaking children. Although the scores were higher for Kannada speaking children, they had more variability. This variability was higher in the initial position than in the medial position.

Table 6: Significance of difference between scores obtained in the initial and medial position between groups.

Position	Group	Mean#	SD	't' value
Kannada	Initial	29.0	4.4	5.1***
Malayalam		23.0	1.7	
Kannada	Medial	29.6	3.9	5.95***
Malayalam		23.06	2.8	

***$p < 0.001$ #Maximum scores = 36

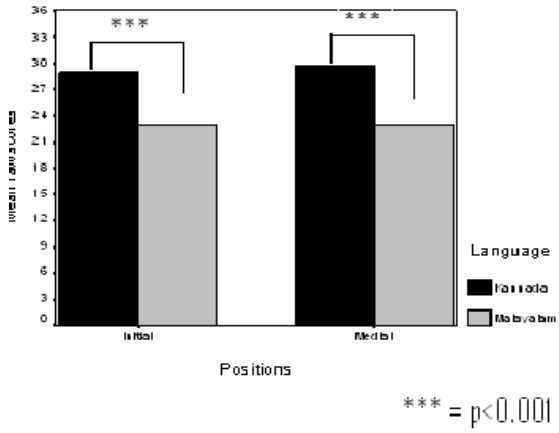

Figure 4: Mean voicing perception scores between the language groups at the initials and medial position

The test retest reliability was checked by administering the coefficient alpha test. On the Kannada group, it was found that the co-efficiency was 0.96 while it was 0.90 in the Malayalam group. This brought a light that test retest reliability was high and that children belonging to both language groups gave reliable responses.

From the findings of the current study it is evident that children with hearing impairment from the two language groups perceive voicing differently, which was found to be statistically significant. This significance of difference was present irrespective of the place of articulation in which it occurred, the vowel combination with which it occurred and the position. The difference in perception of two language groups can be attributed to the difference in the way, voicing is produced in the two languages.

It has been reported by Geethakumary (2002) that voiced stops in the medial position in Malayalam are produced with a gradual trailing in voicing after homorganic nasals (nasals having the same place of articulation). However, she reported that voiced stops were noted to occur in the initial and medial position. In Kannada, no such reduction in voicing has been reported to occur in the presence of homorganic nasals. Though voiced stops do occur in Malayalam, it is possible that the perception of the Malayalam speaking children in the present study were highly influenced by the trailing in voicing that normally occurs in their language. Though no homorganic nasals were used in the present study, probably these children were inclined to not perceive the voice-voiceless distinction.

Though Geethakumary (2002) reported of a trailing of voicing in the medial position, she did not report of any such trailing in the initial position in Malayalam. Hence, it was anticipated that there would be a difference in the way voicing would be perceived in the initial and medial position in the Malayalam group, but not in the Kannada group. However, no such difference was observed. Both language groups showed no significant difference in the way they perceived stop voicing in the initial and medial position. Thus, it can be construed that the trailing voicing in the medial position

alone could not account for the difference in perception of voicing in the two language groups.

Further, it has been reported by Ramakrishna et al. (1962) that the voiceless sounds occur a lot more frequently in Malayalam when compared to the voiced speech sounds. The ratio of voiceless to voiced stops varied from 1:22 to 1:4, where \t\ and \d\ had the highest ratio and \th\ and \dh\ had the lowest ratio. However, in Kannada, the voiced and voiceless contrasts were reported to occur almost equally. Thus, the children exposed to Kannada were stimulated almost equally with voiced and voiceless contrasts, unlike the children exposed to Malayalam, who had unequal exposure to these contrasts. This could have influence their perception of the two groups, resulting in the significant difference observed in the present study.

Conclusion

The results of the study revealed that there existed a significant difference between the way voicing of stops was perceived by Kannada speaking and Malayalam speaking children with hearing impairment. The significant difference was observed at all four places of articulation that were studied (bilabial, dental, retroflex and palatal), vowel environment (\a\, \i\, \u\) and position (initial and medial). However, no significant difference in voicing perception occurred across the four places of articulation, vowel environment or position within each language group. This difference in perception between the two participant groups can be attributed to the difference in the way voicing is produced in the two languages.

Acknowledgements

We would like to thank the Director, All India Institute of Speech and Hearing, Mysore for permitting us to carry out this study.

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