CROSS LANGUAGE PERCEPTION OF VOICING IN CHILDREN WITH HEARING IMPAIRMENT

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CERTIFICATE

This is to certify that this dissertation entitled ***'Cross language perception of voicing in children with hearing impairment'*** is the bonafide work submitted in part fulfillment for the degree of Master of Science (Audiology) of the student (Registration No. 06AUD011). This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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DECLARATION

This is to certify that this dissertation entitled ***'Cross language perception of voicing in children with hearing impairment'*** is the result of my own study and has not been submitted in any other university for the award of any diploma or degree.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Intelligibility is to be found, not in signal themseselves,

But in the brain's organization of the information that the signal supply "

Fry, 1977.

Languages across the world vary in the type of speech sounds they use. A particular phone may be present in one language which may be absent\may occur as allophonic variation in the other. This has captured the attention of various investigators. They have tried to determine whether universality in perception of speech sounds exists or whether the native languages restrict the range of speech sounds which the native language users can perceive.

The voicing of consonants is an important distinction in speech communications, as indicated by statistics of phonological contrasts (Carterette & Jones, 1974). Children with hearing impairment 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 et al., 1967). This confusion has been noted to frequently occur when a voiceless sound is surrounded by strongly voiced sound (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 general voiced and voiceless cues as used by the normal hearing listeners, although some of the impaired listeners may have been unable to make full use of these . cues (Pickett & Revoile, 1983). Listeners with hearing impairment were found to be less sensitive to the vowel-onset transition cues than the normal hearing listeners (Lisker & 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.

Parady et al. (1981) studied the effects of voicing perception for initial stop consonants using synthetic \da\ and \ta\ stimuli in normals and children with hearing impairment. They found that children with severe and profound degree of hearing losses showed reduced ability to differentiate voicing for initial stops, at the VOT boundaries used by normal hearing listeners in stop voicing perception for synthetic stimuli. Thus, VOT seems to be of limited use for those children with hearing impairment in perceiving voicing for initial stop consonants.

Tyler and Summerfield (1980) studied the identification and discrimination task of \ba\, \pa\ and \bi\, \pi\ in normal and moderate hearing loss subjects. They found that identification performance for moderate hearing loss was similar to that of normal hearing subjects. However, on a VOT discrimination task the, listeners with hearing impairment were unable to match the fine discrimination of the normal listeners for both \ba\ versus \pa\ and \bi\ versus \pi\. They required longer VOTs.

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).

The parameters of voicing differ depending on the position of stop consonants in a language. In the initial position, VOT and transition duration are the parameters. While in the medial position, closure duration and transition duration are the parameters for voicing and in the final position it is preceding vowel duration, voicing duration and transition duration (Lisker & Abramson, 1970).

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 (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, Sreedevi & Santosh, 2001).

NEED FOR THE STUDY

Studies of phonemes occurrence in conversation have indicated that the voicing feature is a very important phonological distinction (Mines, Hanson & 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 to know 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.

AIM OF THE STUDY:

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.

REVIEW OF LITERATURE

Several experiments have been conducted to gain insight into the perceptual cues of stop consonants. Lisker (1977) listed 16 parameters that cued voicing in a medial position. These were studied in the words \rapid\ Vs \rabid\. They cues were: presence\absence of low frequency buzz during the closure interval; duration of closure; Fl offset frequency before closure; Fl offset transition duration; Fl onset frequency following closure; Fl onset transition duration; \a\ duration; Fl cut back following closure; Fl cut back before closure; voice onset time (VOT) cut back before closure; VOT delay before closure; F0 contour before closure; F0 contour after closure; amplitude of \i\ relative to \a\; decay time of glottal signal preceding closure and intensity of burst following the closure. The various parameters have been classified as temporal and spectral cues.

The temporal parameters include voice onset time, closure duration, consonant duration, preceding vowel duration, transition duration of preceding vowel, following vowel duration and burst duration. The spectral parameters include frequency of formants, bandwidth of formant, amplitude of formants, direction of second and third formants (F2 & F3) transitions, voice during closure, burst amplitude, burst frequency, F0 changes in the preceding and following vowel and amplitude of the following vowel. It has been found that these parameters are used in combination (Bailey & Summerfield, 1980; Raphael, Dorman & Liberman, 1980) or in trading relation with one another (Liberman & Studdert-Kennedy, 1977; Bailey and Summerfield, 1978; Fitch, Hallwes, Erickson & Liberman, 1980).

Voice onset time as a cue for perception of voicing in individuals with hearing impairment:

Voice onset time as a cue in normal hearing individuals has been defined as the time difference between the release of a complete articulatory constriction and the onset of quasi-periodic vocal fold vibration and is considered a major cue for differentiation of prevocalic stops along with the voicing dimension (Lisker & Abramsom, 1964; Abramson & Lisker, 1965).

Previous studies on initial-stop-voicing perception by listeners with hearing-impairment have examined voicing boundaries, generally for different durations of VOT. Bennett and Ling (1973) employed sets of syllables spoken to produce a continuum of six tokens with a 100 ms range in VOT for each of the stop voicing cognates \b, p\, \g, k\, \d, t\. The normal hearing children demonstrated a definite crossover from 'voiced' to 'voiceless' between the 20 ms and 40 ms VOT and performed at nearly chance identification. In contrast, the children with hearing impairment showed inconsistent voicing distinction of the stops for various VOTs but there was a tendency to identify more voiceless stops for VOTs of 60 ms or greater. It was concluded that children with severe sensorineural hearing loss could not reliably identify voiced and voiceless stops. This finding differed markedly from the conclusion reached by Erber (1972) that children with severe hearing impairment distinguished accurately between voiced and voiceless stops.

The findings of Bennett and Ling (1973) have been supported by a study conducted by Tyler and Summerfield (1980). The latter study evaluated the identification and discrimination of \ba, \pa\ and \bi\, \pi\ in subjects with normal hearing and subjects with moderate sensorineural hearing loss. They found that identification performance for moderate hearing loss was similar to that of normal hearing subjects but on a VOT discrimination task those with hearing impairment were unable to match the fine discrimination of the normal hearing listeners for both \ba\ versus \pa\ and \bi\ versus \pi\. They require longer VOTs.

Parady, Dorman, Whaley and Raphael (1981) studied the effects of voicing perception for initial stop consonants using synthetic \da\ - \ta\ stimuli in children with normal hearing and children with hearing impairment. Two tasks were used in studying perception of the stimuli. In the identification task listeners indicated whether \da\ or \ta\ was heard following each stimulus presentation. In the discrimination task two stimuli with the same or different VOTs were presented consecutively and the listener responded same or different stimuli. The results revealed that children with severe and profound degree of hearing losses showed reduced ability to differentiate voicing for initial stops, at the VOT boundaries used by normal hearing listeners in stop voicing perception for synthetic stimuli. Compared children with moderate degree of hearing impairment, those with severe or profound hearing impairments required longer VOT than normal VOTs for identifying \ta\. Thus, VOT seemed to be of limited use for those children with higher degrees of hearing impairment in perceiving voicing for initial stop consonants.

Revoile et al. (1982) compared the voicing perception in listeners with severe degree of hearing impairment and listeners with normal hearing sensitivity, by altering acoustic cues for initial stops in monosyllable. The syllables were presented at comfortable levels to the better ear of each listener. The results revealed that for the natural unaltered syllables, voicing perception was generally 100% for listeners with normal hearing and between 70% and 100% among the listeners with hearing impairment. In another test conditions, the burst of the syllables with initial voiced stops were cut back by the same amount as the syllables with initial voiceless burs. The results revealed that the syllables with burst deleted for the initial stops yielded reduced voiceless stop perception for the majority of the listeners while fewer listeners showed reduced performance for the voiced stops. However, voiced stop perception was degraded for the majority of the listeners while the syllables with initial voiced stops were cut back according to the duration of voiceless stop burst. Thus, for both the normal hearing listener and listeners with hearing impairment, VOT appeared to be an important cue for initial stop voicing perception especially for voiceless stop.

An assessment of whether young listeners with hearing impairment were as sensitive as normal hearing individuals to the cues for stop consonant voicing was studied by Whaley and Dorman (1984). They presented stimuli along a VOT continuum to young normal hearing listeners and to listeners with mild, moderate, severe and profound degree of hearing impairments. They found that the listeners with normal hearing sensitivity and those with mild and moderate degree of hearing impairment did not differ in performance on any response measure. They also found that the listeners with severe degree of hearing impairment did not show the expected change in VOT boundary with changes in place of articulation.

Johnson and Dorman (1984) evaluated the ability of young listeners with hearing impairment, as compared to normal hearing children, to discriminate the cues for stop consonants voicing. The stimuli used were three formant approximation of the stop consonant vowel syllables \ba\, \da\, ga\, \pa\, \ta\ & \ka\. A continuum of 10 stimuli varying in VOT was generated for each place of articulation. The results revealed that the listeners with normal hearing sensitivity and those with mild and moderate hearing loss did not differ in performance in a discrimination of \ba-pa\, \da-ta\, \ga-ka\. It was found that listeners with severe impairments did not show expected changes in VOT boundary with change in place of articulation. Based on this result they concluded that the cochlear damage that underlies mild and moderate hearing impairment did not significantly alter the auditory representation of VOT. However, the cochlear damage underlying severe impairment possibly interacting with signal presentation levels did alter the auditory representation of VOT.

Revoile et al. (1987) studied the cues to voicing perception of initial consonants in children with hearing impairment having moderately-severe to severe degree of loss and children with hearing sensitivity within normal limits. The results of this study confirmed that VOT was a strong voicing cue for both the children with hearing impairment and children with normal hearing. They found that when the aspirations of the voiceless stops were inserted between the release and the vowel of the voiced-stop syllables, the normal hearing listeners perceived voiceless stops predominantly. It was found that the transition portions of the vowel onset contained strong cues for voicing perception. The children with hearing-impairment seemed to be less sensitive than the normal hearing children to the presence of aspiration and the vowel-onset cues.

From the studies reported in literature regarding VOT perception in individuals with hearing impairment, it can be noted that the degree of hearing impairment played a role in the perception. In general it was found that those with a mild-to-moderate degree of hearing loss, perceived VOT like normal hearing individuals. However, those with higher degrees of hearing impairment usually required longer VOTs to perceive voiceless stops.

Influence of the first formant on the recognition of voiced stop consonants:

Dorman, Lindholm and Hannley (1985) evaluated the influence of the first formant on the recognition of voiced stop consonants by listeners with hearing impairments. They found that removal of the first formant did not improve intelligibility and thus, it was suggested that masking spread from the first formant was not a significant factor in the identification of voiced stop consonants by listeners with sloping, mild-to-moderate hearing loss.

Hazan and Fourcin (1985) and Hazan (1986) examined predominantly profoundly hearing-impaired children for their use of VOT and \ or the first formant (Fl) transition at vowel onset for perception of a synthetic *goat* versus *coat*. The children relied primarily on the Fl transitions for this distinction.

The limited studies on the importance of Fl in the perception of voicing indicate that the degree and slope of the audiogram influenced its cueing property. It did not mask important cues in those with lesser degrees or those with sloping hearing loss. However, those with profound hearing loss depended on it to perceive voicing contrasts.

Closure duration as a cue for perception of voicing in individuals with hearing impairment:

Closure duration has been considered as the interval of closure indicating the time for which the articulators are held in position for a plosive and is measured as the time duration between the onset of the closure to the onset of the following phoneme.

It has been established by several studies (Lisker, 1957; Ahmed and Gupta, 1980; Datta, 1989; Savithri, 1989) that silence played an important role in the perception of manner, voicing and place features of stop consonants. Depending on the duration of the silence between the syllables, the intervocalic stops in trochees were perceived as voiced or voiceless in words like rapid or rabid (Lisker, 1957). Port (1979) reported that 'rapid' being perceived as 'rabid', when the duration of silence between the syllables was reduced.

Lisker (1957) reported that the closure durations of voiced stop consonants were shorter than those of the voiceless in English. In Kannada also the same was reported (Savithri, 1986). The results indicated that children with hearing impairment had significant longer closure duration than their normal counterparts.

Preceding vowel duration as *a cue for perception of voicing in individuals with hearing impairment:*

Preceding vowel duration is the duration of vowel preceding the target consonant and is measured as the time differences between the onset and offset of the vowel.

Preceding vowel duration is found to be one of the cues for voicing in stop consonant. Typically vowels are longer before voiced than before voiceless consonants (House and Fairbanks, 1953; Peterson and Lehiste, 1960; House, 1961).

Revoile, Pickett, Holden and Talkin (1982) examined listeners' sensitivity to the cues for syllable-final stop voicing. They found that some listeners with hearing impairment were critically dependent on the vowel-duration cue. Others were sensitive to the voiced murmur, the final voiceless bursts, or both, as cues and fewer listeners were able to perceive the transition cues, which were useable by listeners with normal hearing.

Hedrick and Jesteadt (1996) evaluated the effect of relative amplitude, presentation level, and vowel duration on perception of voiceless stop consonants by normal hearing and listeners with hearing-impairment. They found that there was no significant difference present between listener groups when only relative amplitude was manipulated, but significant difference was present when both relative amplitude and formant transition information was present. These results suggested that the listeners with normal hearing weighted the two acoustic cues differently from listeners with sensori neural hearing loss. It was also found that increasing vowel duration generally increased the number of labial responses from listeners with normal hearing, but did not always increase the number of labial response from listeners with sensori neural hearing loss.

Transition duration of preceding vowel as *a cue for perception of voicing in individuals with hearing impairment:*

Revoile, Pickett, Holden, Pitt and Talkin (1982) found the importance of vowel transition as an important cue for the perception of voicing in final-stop consonants. They studied the different acoustic cues necessary for the perception of final stop voicing in listeners with hearing impairment. In their study, they progressively neutralized the cues in naturally spoken syllables. The cue modifications consisted progressive of neutralized vowel duration, equalized occlusion duration, burst deletion, murmur deletion, vowel transition interchange, and transition deletion. The listeners with moderate-to-severe degree of hearing loss showed at least 70% correct voicing for the unmodified syllables. It was also observed that for the voiced stops, vowel-duration adjustment and murmur deletion resulted in significant reduction in voicing perception for more than one-third of the listeners with hearing-impairment. However, all subjects with normal hearing showed good performance following neutralization of these cues. For the voiceless stops, it was found that a large percentage of both listener groups performed well even after the vowel duration adjustment and the burst deletion. When the vowel off going transition were exchanged between cognate syllables, listeners with hearing-impairment and all listeners with normal hearing implicated that the vowel transition was an important additional source of cue for the perception of voicing in final-stop position.

Revoile, Pickett, Pitt, Talkin and Brandt (1987) studied the use of cues to voicing perception of initial stop consonants in normal hearing and children with hearing impairment. They found that transition portions of the vowel onset in burstless contained strong cue for voicing perception.

Following vowel duration as a cue for perception of voicing in individuals with hearing impairment:

Vowel duration is an important parameter which provides information on the prosodic as well as linguistic aspects of speech. Vowel duration is the duration from the onset of vowel to its offset.

Revoile et al. (1987) has examined the acoustic cues for final stop voicing perception in normal hearing listeners and listeners with hearing impairment. Both the groups identified syllables with \p\, \t\, \k\, \b\, \d\ or \g\. Responses were scored according to correctness of stop voicing perception, regardless of consonant place errors. Among different test conditions, various acoustic cues to final stop voicing were altered in the syllables. It was found that perception for final voiced stops was reduced for a third of the listeners with hearing impairment, when vowel duration was made similar between syllables with voiced versus voiceless consonants. For the normal listeners, perception was minimally affected by this adjustment to vowel duration. Voiced stop perception was also reduced for some listeners with hearing impairment, when in addition to the adjustment of vowel duration, the voiced murmur was deleted between the vowel and the release burst of the final stop. It was also found that the voicing perception for the voiceless stops showed generally a similar pattern of performance between the normal hearing listeners and listeners with hearing impairment. However, the performance was generally better for the normal hearing group. When the vowels were made similar between the syllables with voiced and voiceless stops, nearly one of the listeners with hearing impairment and normal listeners showed reduced voicing perception for the final voiceless stops. Perception was decreased for more than half of the listeners for the voiceless stops, when the bursts were removed from the syllables, when the off going transitions of the vowels were interchanged between syllable pairs of opposite stop voicing. The level of voicing perception seen for many of the listeners with hearing impairment and normal hearing listeners indicated that the vowel transition were an important additional source of cues to the final stop voicing perception.

Burst duration as a cue for perception of voicing in individuals with hearing impairment

It was found that burst duration was an important acoustic event and cued the perception of voicing and place of articulation (Savithri et al., 1995). The results of experiments done by Savithri et al. (1995) revealed that there was no significant difference between the mean, SD and range of burst duration of normal children and children with hearing impairment. It was found that in normal children the longest burst duration was noticed for velars followed by bilabials, dentals and retroflexes. In children with hearing impairment, burst duration decreased from velars, bilabials, dentals to retroflex. On the average, for voiced plosives velars had the longest and retroflex had the shortest burst duration in both the groups.

Perception of voicing in Indian languages:

Several studies have been conducted in Indian languages regarding the acoustical cues used during production or perception of voicing in stops. A few of these studies dealing specifically with Malayalam and Kannada are reviewed below.

An examination of spectrogram of \b\ and \p\ taken from a Malayalam speaker and those provided by Williams (1980) revealed that the stop consonants in Malayalam are entirely different from that of English in that those in Malayalam do not have aspiration, and Fl cut back. Neither aspiration in the lag VOT region, nor F1 cut back is present in Malayalam stop consonants. These differences in the acoustic properties of stops in English and Malayalam might be reflected in the perception also with a 50% cross over in the lag VOT region for English and short lag VOT region for Malayalam.

Sreedivya and Savithri (1997) evaluated the cross language perception of stops in Tamil and Malayalam language. The results revealed that the perceptual data was correlated with production data. On the voicing contrasts, Tamil monolinguals showed the poorer performance, which is expected as voicing is not phonemic in Tamil. Performance of the subjects improved when a combination of cues (aspiration and place, aspiration, voicing and place, place and voicing) was used than each of these in isolation. Bilinguals performed better on voicing and aspiration contrasts which in phonemic in Malayalam.

The results obtained from Rahul (1997), Jayaprakash (1998) in Kannada, Priya (1998) in Malayam, Kanaka in Tamil (1998) and Poonam (1998) in Punjabi, revealed that vowel duration was significantly longer in group with hearing impairment compared to the normal group. This may be because of the poor motor coordination. The authors opined that the children with hearing impairment in their studies heavily depended on vision and vision did not permit rapid movement unlike audition. The high range of vowel duration in hearing impaired children may reflect the greater variability exhibited by the hearing impaired children.

George and Savithri (2003) carried out a cross language study of consonant perception for Hindi and Malayalam languages. The results revealed that Malayalam monolinguals scored higher than Hindi monolinguals and Malayalam bilinguals which were expected. Malayalam monolinguals and Malayalam bilinguals scored higher on perception of stop consonant compared to Hindi monolinguals. Hindi monolinguals perception of lax consonants was poorer compared to Malayalam monolinguals and bilinguals. This was expected as Hindi does not have lax consonants in their phonetic inventory. The results indicated that speakers of Hindi language have difficulty in perceiving differences in phonemes that are not present in their language.

The Hindi listeners' ability to discriminate Malayalam lateral contrasts and the differences between adults and children in the ability to discriminate such contrasts was studied by Agrawal and Savithri (2005). Malayalam language has 3 laterals-alveolar, retroflex and palatal-and Hindi has only the alveolar lateral. The results indicated that native Malayalam speakers discriminated the palatal-retroflex contrast better than the retroflex-alveolar contrast. The non-native speakers discriminated retroflex-alveolar contrast better than palatal-retroflex contrast. Native Malayalam speakers discriminated both laterals better than non-native Hindi speakers.

In yet another cross-language study on Indian languages, Anjali and Savithri (2007) evaluated the perception of voicing, aspiration and murmur by Malayalam (native) and Tamil (non-native) speakers. As voicing, aspiration and murmur are not phonemic in Tamil it was expected that Tamil speakers would perform poorer on tasks involving these parameters. These contrasts were evaluated using a discrimination task. The results of this experiment revealed that there was no significant difference between languages (native and non-native speakers) in their response to the VOT continuum. Also, there was no difference between the three places of articulation in Malayalam and Tamil. Malayalam speakers shifted their percept from voiced to voiceless in all places of articulation. However, Tamil speakers did not shift their percept from voiced to unvoiced in velar place of articulation. Also, the shift was not above 60% for the \d-t \ continuum in Tamil speakers. The percept changed from voiced to unvoiced stops (whenever it happened) in the lag VOT region in both languages. In Tamil, voicing is not phonemic while in Malayalam it is phonemic in the word-initial position. Therefore, it was expected that Tamil speakers would not be able to shift their percept from voiced to unvoiced stops. The results reflected this aspect as Tamil speakers did not shift their percept from voiced \g\ to unvoiced \k\. Further, even when there was a shift in the percept from \d\ to \t\, Tamil speakers were also not able to identify \t\ 75% of times. However, Malayalam speakers were also not able to identify \p\ 75% of times. This may be because of the status of voicing in Malayalam. Voicing is phonemic in word-initial position in Malayalam and there is a lax consosnts in the word-medial position. Therefore, it is likely that Malayalam speakers are confused with voicing.

Considerable research has been undertaken regarding the acoustical cues used for the perception of stops in Kannada. Rajapurohit (1982) studied the duration of consonants in Kannada language. He found that duration of consonants in the medial position was less than in initial position and the duration of consonants before aspiration was 25-60% less than duration elsewhere.

Savithri (1986), in her study on duration of stop consonants in Kannada has reported that in general, the voiceless stops were longer than the voiced stops and in particular, retroflexes were the shortest and palatals were the longest. It was found that, both in normal children and children with hearing impairment, consonant duration of unvoiced stops were longer compared to voiced stops. However, in children with hearing impairment, consonant duration was also one of the parameters used to differentially produce voiced and voiceless stops. This indicated that children with hearing impairment were not as efficient as the normal children in the use of consonant duration to differentiate voiced and unvoiced stops.

The importance of the preceding vowel duration in Kannada in the perception of stop voicing studied in adults (Usharani, 1989; Vinay Rakesh, 1990) and in children (Savithri, 1995). In these studies the stops in medial position were considered and the results indicated that preceding vowel duration did not act as cue to voicing. Though Indian languages like Kannada and Telugu do not use stops in the final position. Kannada language has borrowed English words with final stops. The results revealed that the preceding vowel duration did not emerge as a cue for voicing in the final position in the normal and hearing impaired children. This was in contrast with the study of Crowther and Mann (1990), Hogan and Rozypal (1980), Raphael (1981) and Revoile etal (1982) who had classified preceding vowel duration as a generally sufficient cue for final stop voicing. Their findings regarding the preceding vowel duration were in agreement with those of Wardrip-Fruin (1982) who showed that vowel preceding final voiced stops could be reduced in duration by one-third without eliciting voiceless responses. Thus, it appeared that preceding vowel duration was not a cue for voicing in stop consonants in Kannada language.

The development of closure duration as a cue to voicing of stop consonants (p, t, and k) in 3-6 year old Kannada speaking children was evaluated by Sathya (1992). The results obtained revealed that at short closure duration, voiced percept was identified and at longer closure duration, voiceless percept was identified. The results revealed that closure duration operated as a cue for voicing of stop consonants in 3-6 years old children.

In the Indian context, Shanthi, Nandini and Savithri (1992) studied the importance of closure duration as a cue to place and manner of articulation of the velar and dental stop consonants in Kannada. The result indicated that closure duration was a cue for the place and manner of articulation in Kannada. Reduction in closure duration brought about a change in place of articulation first and with further reduction there was a change in manner of articulation.

Savithri and Sridevi, (1991) studied the perception aspects of closure duration in children aged between 4-7 years in Kannada. The results on speech perception indicated that closure duration operated as a cue for voicing of stop consonants. It was found that in normal children, closure duration of unvoiced stops was longer compared to voiced stops. However, in children with hearing impairment, closure duration of voiced stops was longer than that of unvoiced. This indicated that children with hearing impairment were nor efficient in the use of closure duration to differentiate voiced and unvoiced stops.

Using the Indian languages Kannada and Hindi, Usha Rani (1989) studied the effect of five temporal parameters (closure duration, preceding vowel duration, transition duration of preceding and following vowel and voice onset time) on the perception of bilabials and velar unaspirated geminate stop consonants in Kannada and Hindi speakers. She found that there was no significant difference in the percept by the listeners of Kannada and Hindi languages.

The results of the cross-language studies by Savithri and Sreedevi (1991) and Sathya et al. (1992) indicated that language plays a significant role in the perception of voicing. Depending on the nature of stop consonants available in a particular language, the voicing contrast differed.

A few studies have also been conducted on perception of stops in other Indian languages. Lahiri (1980) acoustically analyzed word initial stops of Hindi, Punjabi and Bengali and reported that the feature interrupted voicing differentiated the so-called voiced aspirates from the other three categories. These stops were reported to be characterized by a pattern of pre-voicing followed by approximately 100 ms of silence and then resumed phonation. The other stop categories of these languages were reported to be characterized by lead, coincident and lag VOT.

Werker and Tees (1984) studied English speaking adults' ability to discriminate the Hindi contrast voiceless aspirated (th) vs. breathy voiced (dh). They could not discriminate this contrast. A limited training of 25 trials was sufficient to facilitate the discrimination of this voicing contrast. This VOT boundary cross over is distinctive in English and hence it could be easily acquired.

Savithri and Santosh (2001) investigated the voicing contrast of stop consonants in 15 Indian languages: Assamese, Bengali, Gujarathi, Hindi, Kannada, Kashmiri, Kodava, Malayalam, Marathi, Oriya, Punjabi, Rajsthani, Tamil, Telugu and Tulu. They measured five acoustic parameters to understand the voicing characteristics of these languages. It was found that among the host of parameters, in most of the Dravidian and Indo-European languages, VOT contrasted voicing in word-initial position. However, variations among languages were also observed. In the word-medial position, the voicing contrast was by closure duration or total duration. In Tamil and Malayalam the voiced and weakly voiced plosives were not contrasted by any of the parameters studied. In Hindi, the contrast was poor. In word final position, preceding vowel duration appeared to contrast voicing in Kashmiri, Bengali, Hindi and Marathi. It was found that in contrast to the finding in other non-Indian languages, vowel duration preceding unvoiced plosives were longer than those proceeding voiced plosives in all Indo-European languages except Gujarathi.

Cross language Perception of voicing contrasts

Representation of cross language voicing contrasts has been a problem since the mapping between phonological categories and their physical phonetic realizations is not one-to-one. Keating (1984) has argued that the representation of such contrasts for stops consonants must involve purely abstract features (+voice) and (-voice), which map onto phonetic categories for stops based on VOT in different ways for different languages.

When languages have a 'traditional' voiced vs. voiceless stop contrast in the initial position (e.g. Arabic, Bulgarian, Efik, Japanese), with no aspiration involved, then VOT has been used in particular to differentiate the two. The differences in VOT have been termed lead vs. short lag for voiced and voiceless respectively (Lisker & Abramsom, 1964; Keating, Mikos & Ganong, 1981). Across languages there appears to be a fairly consistent 60 ms minimum difference in VOT between voiced and voiceless stops (Lisker & Abramsom, 1964).

The influence of linguistic knowledge is one of the important aspects in speech perception. Lotz, Abramson, Gerstman, Ingemann and Nemser (1960) studied the perception of English stops by speakers of English, Spanish, Hugarian and Thai using tape-cutting method. They concluded that there was a hierarchy among the cues in the acoustic stimulus for the perception of stops in various languages. For American English, the lack of aspiration was a dominant cue for forcing the evaluation of the stops in the direction of \b, d, g\, whereas in the language where the distinction existed, the evaluation was different. These exemplify the reflection of the linguistic categories of the listener's native language in the perception of speech sounds.

Singh and Black (1966) studied the production and perception of twenty-six intervocalic consonants in the speakers of four languages (Hindi, English, Arabic & Japanese). They reported that listening groups differed and that consonants were unequal in their intelligibility. On the whole, all speakers spoke better and all listeners listened better when saying and hearing sounds of their native language.

Lisker and Abramson (1970) carried out perceptual studies using synthetic stimuli varying in VOT. The stimuli consisted of labial, apical and velar stop consonants. English, Thai and Spanish natives showed that their identification and discrimination function and boundaries were determined by their native language. Goto (1971) studied adult learners and found that adult bilinguals were often quite insensitive to perceptual distinctions in their non-native language, even if they can produce them. Japanese speakers judged by Americans to be making the English \r\-\l\ distinction appropriately as they produced words such as 'lead', 'read', nevertheless found difficulty in perceiving the distinctions. In another study, Lisker and Abramson (1972) attempted to train native speakers of Russian to distinguish between the voiceless unaspirated and voiceless aspirated stop. This voicing distinction was in English but not in Russian. Although Russian subjects learned to identify the end point stimuli (i.e., +10 ms and +60 ms in VOT) slightly better than chance, their performance was not the same for both the stimuli. Though they could use two discrete labeling responses their performance on the task was neither consistent nor reliable. Since no immediate feedback were provided after the training trial, they probably had more difficulty in determining which specific acoustic attribute of the stimuli to attend selectively.

VOT as a linguistic cue to separate word-initial stop consonants in three groups of participants viz., unilingual Canadian, French and English and bilingual French-English speakers were studied by Caramazza and Yeni-Komshian (1973). They used an identification task. The results revealed that unilingual English speakers had sharp monotic slopes in their perceptual functions, this being absent for unilingual French participants. Bilinguals had steeper slopes but non-monotic, cross-over points in the intermediate position. This lack of monocity indicated that the first learned language interfered in the perception.

Miyawaki et al. (1975) assessed perception of synthetic \r\ - \1\ continua by native Japanese, native bilingual Japanese speakers with English as their second learned language in adulthood and native American English speakers. The continuum varied on F3 formant considered as primary cue for contrast in English. The results showed that whereas English listeners were successful in categorical perception, the Japanese listeners both monolinguals and bilinguals were unable to do so and discrimination was nearly random.

In an investigation on the role of VOT in distinguishing among Korean apical stop consonants, Moslin and John (1976) measured VOT for word initial apical stops in the speech of four native Korean speakers. They found that VOT values for word-initial apical stops in the speech of all four speakers showed considerable overlap of the weak and unaspirated categories. The data suggested that although VOT was sufficient to distinguish the strong from the aspirated stops, it could not effectively distinguish either of them from weak stops.

Elman, Diehl, and Buchwald (1977) found that the language set the listeners have when making decisions about speech sound identity is capable of changing the boundary between categories. Bilingual participants divide stimuli according to the phonemic contrasts of the particular language they are using immediately before each stimulus.

Strange and Jenkins (1978) attempted to modify voicing perception in adults. A small number of college-age students were trained to identify and discriminate differences in the lead region of VOT continuum in which Thai voiced\voiceless unaspirated boundary occurs. They found that only a small change in the perceptual categories with performance improving in the target region of VOT continua where identification and scaling procedure was used. Participants failed to generalize from one VOT series to another and the results were marked by high variability.

However, Fox and Lehiste (1989) who studied discrimination of duration ratios in bisyllabic token by native English and Estonian listeners, concluded that neither the linguistic background of the listener nor the linguistic status of the stimulus token (i.e. noise burst or bisyllables) seem to have a significant effect upon the ability to make precise discrimination.

Using different VOTs, Ohde (1978) examined the perceptual strategies used by listeners. It was reported that 55 ms VOT was rated as p-like and 5 and 25 ms VOTs were rated as b-like. Keating (1979) measured VOT differences in production and perception of Polish and English stops in minimal pairs. Sentences and conversation, the VOT distribution for voiced and voiceless stops were clearly separated in Polish but not always in English, especially in causal speech. The Polish VOT led to perceptual categories that were somewhat unstable and did not always match the VOT production categories. In contrast, the English perceptual categories were quite stable.

Williams (1979) established the monolingual identification boundaries for \b\ and \p\ and the discrimination peaks for both English and Spanish speakers. She found that their production of \b\ and \p\ in word-initial position corresponded to their perception. English speakers separated the phonemes at about +25 VOT, while Spanish speakers put the boundary at about -4 VOT. Spanish speakers learning English varied more than monolinguals in the crossover points of their identification functions, and the discrimination peaks spanned both the monolingual Spanish and English boundaries.

In a second study, Williams tracked changes in production and perception in young Rican Spanish-speaking children who were learning English. She found the labeling crossover point gradually shifting towards the English boundary as exposure to English increased. In production, the children were using VOT patterns closer to English, both in their English and Spanish words.

Pisoni and Lively (1982) studied the perception of stops differing in VOT in two different conditions by two groups of native participants. In the first condition, they used two response categories, corresponding to phonemes \b\ and \p\. In the second condition, they were provided with three response alternatives \b\, \p\, \ph\. They showed reliable 2-category and 3-category identification function. Two additional groups of participants were studied in another experiment using the same stimuli and in addition to identification function, discrimination (AxB) function was also carried out. They could discriminate stimuli in the voicing lead region despite being identified as belonging to same perceptual category. A discrimination training procedure with immediate feedback was carried out. Training was presented in a predictable order using only three stimuli, one from each of the three voicing types (-70 ms, 0 ms, +10 ms). After training, those who met a predetermined criteria were tested for identification and discrimination function. The participants were highly consistent in labeling the sounds in the voicing lead region of the continuum. Steeper slopes in identification function were obtained. Thus, within a short period of time, native English speaking adults could acquire the non-native contrast in voicing using simple laboratory training.

Flege and Hillenbrand (1987) studied the differential effect of release burst on stop voicing judgment of native French and English listeners. When the release burst was removed from the word final English \g\ tokens, the voicing judgments of native French speakers were influenced but no effect was seen in native English participant. French natives gave more emphasis on release burst, as the stops are consistently released in French.

Flege, Bohn and Jang (1997) studied language set effects in Spanish and English monolinguals and bilinguals. The stimuli used were short-lag Spanish \t\, Spanish \d\ with context effect was observed for Spanish and English monolinguals and bilinguals. The Spanish \t\ tokens were presented in Spanish and English perceptual sets. A small 'language set' effect was observed for the monolingual and bilingual listeners. Since both the groups showed the same effects, a post-perceptual language independent decision strategy based on their language-dependent perceptual could have been employed.

Crowther and Mann (1990) carried out experiments to test the hypothesis given by Chen (1970) that preceding vowel duration was a universal cue to final consonant voicing in CVC monosyllables. They compared native speakers of Mandarin, Chinese, English and Japanese. Their experiment revealed that native speakers of English showed the strongest implementation and sensitivity to vocalic duration as a cue to consonant voicing. Mandarin, Chinese and Japanese show a weaker effect. While there may be a universal tendency to lengthen the vocalic portion before voiced stop, the magnitude of contrast seems to be determined by language specific considerations.

It is evident from the above literature that several cues are used for the perception of voicing in stops. These cues are found to vary from language to language. Though several studies have been conducted on Indian languages, the variations in the perception of voicing contrasts have not been evaluated. The lack of studies in these languages warrants research in this area.

METHOD

The study was done with the aim to evaluate the effect of regional language on the perception of voicing of stop consonants in the children with hearing impairment. Voice-voiceless perception in four places of articulation (bilabials, alveolar, retroflex and palatal), in two positions (initial and medial) and with three vowel environments (\a\, \i\, \u\) were aimed to be evaluated.

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. The subjects met the following criteria:

- They had moderate to severe degree of hearing loss,
- They did not have any middle ear disorder,
- They used BTE hearing aids for at least 4 years,
- Their aided thresholds were within the speech spectrum at least up to 2 kHz,
- 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,
- They did not have any neurological problems and
- They did not have other physical disability.

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 participant's selection and for the presentation of the stimuli.
- An immitance meter GSI-Tympstar provided information regarding the middle ear function.
- A computer was used for presenting the stimuli to the participants.

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 S3.1991, cited in Wilber, 1994). The development of the material for 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 in each set. 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 speaker was used since speakers of Malayalam tend to produce voiceless stops with a trailing voicing (Geethakumary, 2002). The recording was done on a Pentium IV computer using the Adobe Audition Software. 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 materials were normalized using the Adobe Audition software so that all the speech stimuli were of same intensity. These were digitally recorded on a computer with a 16 bit Analog to Digital Converter (ADC) at a sampling frequency of 16 kHz. 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 were done to determine the hearing threshold of the participants using a Madsen OB-922 diagnostics clinical audiometer which was calibrated according to ANSI S3.6-1996 (cited in Wilber, 2002), with TDH-39 ear phones and B71 bone vibrator. 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 GSI-TS impedance audiometer, which was calibrated according to ANSI S3.39-1987-R, 1996 (cited in Wilber, 2002) 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 the children were trained using the 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. 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. All stimuli were randomized to avoid any order effect.

Scoring

The response of the children was 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.

RESULTS AND DISCUSSION

The effect of regional language on the perception of voicing of stop consonants in the children with hearing impairment was analyzed. The raw data obtained from the two groups of children with hearing impairment, speaking Kannada and Malayalam were analyzed using the Statistical Packages for Social Sciences (SPSS) software version 15. The data obtained from the eighteen children with hearing impairment (10 Kannada speaking & 8 Malayalam speaking) were analyzed in order to get information regarding the following:

1. **Perception of voicing within and between language groups**
   1.1 Perception of voicing in Kannada speaking and Malayalam speaking children
   1.2 Comparison of perception of voicing between Kannada and Malayalam speaking children
2. **Effect of place of articulation on discrimination of voicing within and between language groups**
   2.1 Effect of place of articulation on discrimination of voicing in Kannada and Malayalam speaking children
   2.2 Effect of place of articulation on the discrimination of voicing between Kannada and Malayalam speaking children
3. **Effect of vowel on the perception of voicing within and between language groups**
   3.1 Effect of vowels on the perception of Kannada and Malayalam speaking children.

3.2 Effect of vowels on the perception of voicing Kannada and Malayalam speaking children

4. Effect of position of stop on voicing perception within and between groups

4.1 Effect of position of stop on the discrimination of voicing in Kannada and Malayalam speaking children

4.2 Effect of position of stop on the discrimination of voicing between Kannada and Malayalam speaking children

To obtain the above information, besides doing a descriptive statistics, mixed ANOVA, repeated measure AN OVA and independent't' test was carried out. Details of results are further discussed.

1. 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 Table 1. These scores represented the responses obtained to all 72 stimuli for each language group.

Table 1: Mean and standard deviation (SD) of the overall scores of the two language groups

Language	N	Mean*	SD
Kannada	10	57.9(81%)	7.58
Malayalam	8	46.7 (65%)	3.34

#Maximum score = 72

1.1 Perception of voicing in Kannada and Malayalam speaking children

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

1.2 Comparison of perception of voicing between Kannada and Malayalam speaking children

In order to check whether the discrimination scores differed from each other, 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 depicts these findings.

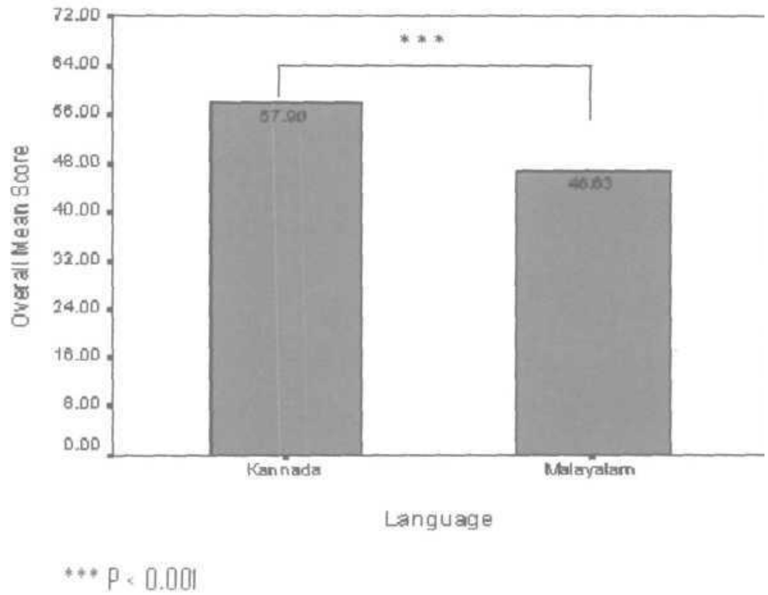


Figure 1: Mean total raw score for the Kannada and Malayalam speaking groups

2. 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. In order to determine the difference, mixed ANOVA (repeated measures within group and language as independent factor) was done. The results revealed that the scores were better for the Kannada speaking children with hearing impairment compared to the Malayalam speaking children with hearing impairment. The mean scores for voicing as a measure for place of articulation was more for the Kannada speaking group. The results also revealed that when all the four place of articulation was compared within the each group the results were better for velar stops compare to other place of articulation. The mean and SD obtained for the two groups is shown in Table 2.

Table 2: 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

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 languages, Kannada and Malayalam [$F(l, 16) = 15.199$, $p < 0.01$)].

2.1 *Effect of place of articulation on discrimination of voicing in Kannada speaking and Malayalam speaking children*

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 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.

2.2 Effect of place of articulation on the discrimination of voicing between Kannada and Malayalam speaking children

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 dentals stops ($p > 0.05$). This is depicted in Table 3 and Figure 2.

Table 3: 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.

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. The performance of the Kannada group was slightly lower for this place of articulation resulting in no significance of difference.

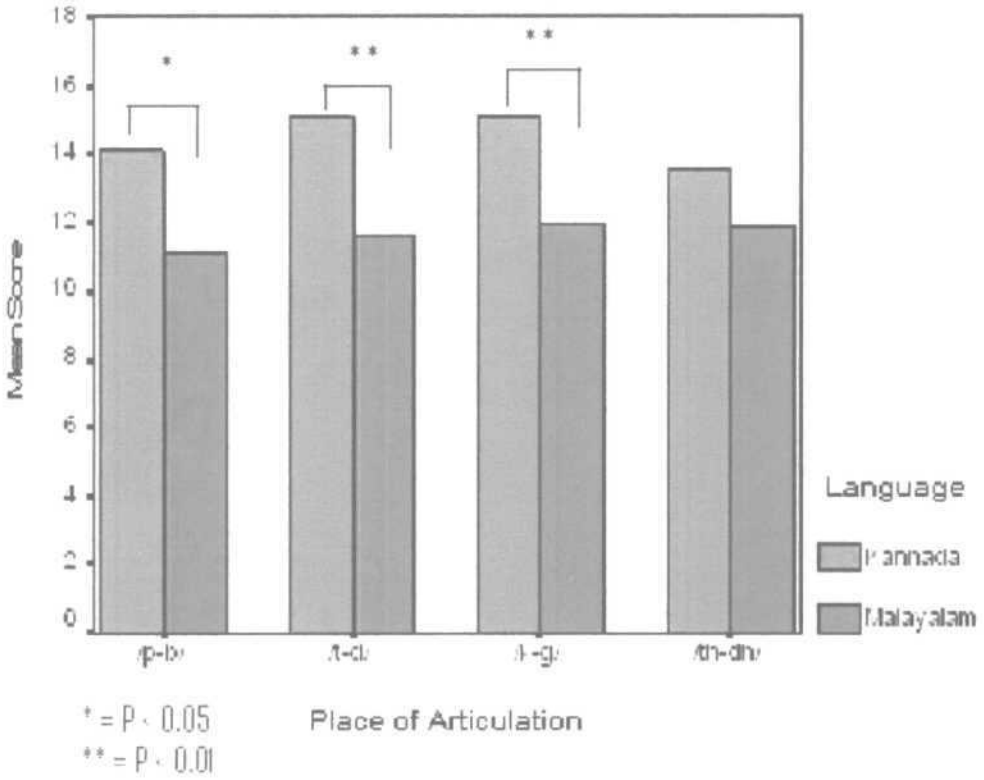


Figure 2: Mean voicing perception scores between the language groups at four places of articulation

3. 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 4 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 4: 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

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 [$F (1, 16) = 15.199$, $p < 0.01$)].

3.1 Effect of vowels on voicing perception in Kannada and Malayalam speaking children.

Separate one-way ANOVAs were performed on the Kannada speaking group and the Malayalam speaking group to determine the influence of vowels in 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.

3.2 Effect of voicing with respect to vowel between Kannada and Malayalam speaking children

A significant effect of the vowel context on voicing perception between the two language groups was obtained in the mixed ANOVA [$F(1, 16) = 15.199$, $p < 0.01$)]. 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 5).

Table 5: 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	

*Significance at 0.05 level of significance

***Significance 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 (Table 5). Figure 3 depicts the mean scores for both the group for all the three vowel environments.

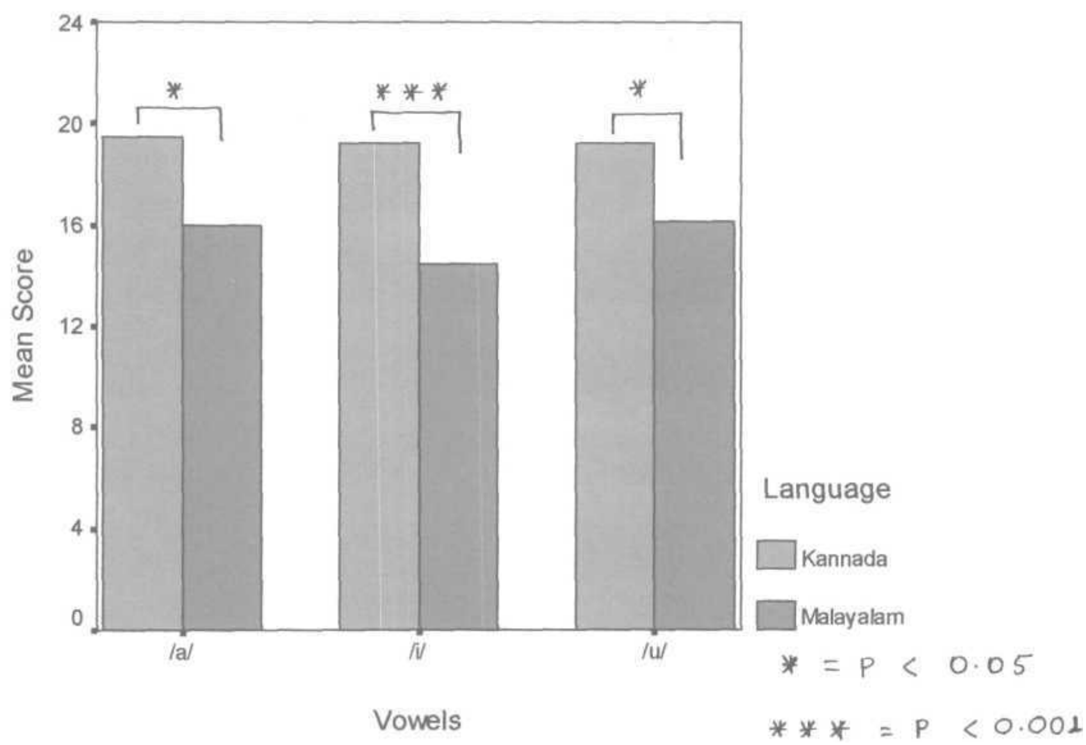


Figure 3: Mean voicing perception scores between the language groups at three vowel environment

4. 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 effects the voicing perception in each of the language groups. Within each language group, it can be noted from Table 6 that the mean values were very similar for stops occurring in the initial and medial position. However, the scores as well as SD values were higher for the Kannada group than for the Malayalam group.

4.1 Effect of position of stop consonant on voicing perception in Kannada and Malayalam speaking children

A paired sample 't' test was performed to assess the effect of initial and medial position of stop consonants on voicing perception in Kannada and Malayalam. 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 6: 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

4.2 Effect of position of stop consonant on perception of voicing between language groups.

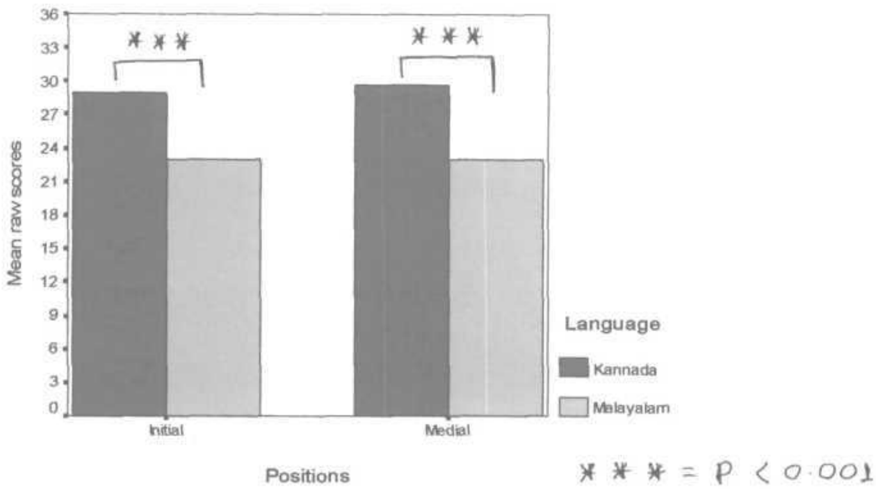
A paired sample 't' test was performed to assess the effect of position of stop consonants on voicing perception between the Kannada and Malayalam groups. The results of paired sample 't' test revealed there was a highly significant difference in the mean scores for each position between language groups. The mean, SD and't' value are depicted in the Table 7. 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 7: 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

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



To determine test retest reliability, coefficient alpha test was administered. 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 and the vowel combination with which it occurred. The difference continued to be present in the initial and medial 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 (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.

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 findings of the present study can be summarized as follows:

- An overall significant difference between the two language groups was observed in their ability to perceive voice-voiceless stops.
- A significant difference occurred at all four places of articulation that were studied (bilabial, alveolar, retroflex and palatal) in voicing perception.
- No significant difference in voicing perception occurred across the four places of articulation in both language groups.
- A significant difference between language groups occurred at all three vowel combinations (\a\, \i\, \u\).
- No significant difference occurred across the three vowel combinations.
- At both initial and medial position, a significant difference between language groups occurred.
- No significant difference was observed between the initial and medial positions.

SUMMARY AND CONCLUSION

It was reported by various studies on phonological contrasts (Denes, 1963; Carterette & Jones, 1974) that the voicing of consonants is an important distinction in speech communication. It was found that children with hearing impairment usually have difficulty in both discrimination and production of the voiced-voiceless contrast. They tend to confuse voiced contrast with voiceless consonants and vice versa. It has been reported in literature that one factor that affects perception of voicing is a peripheral hearing loss. Apart from this it was found that the spoken language plays a significant role in the perception of voicing. Depending on the nature of stop consonants available in a particular regional language, the voicing contrast differed from one language to other. In Malayalam, voiceless stops have found to be produced with a trailing voicing in the medial position along with homorganic nasals (Geethakumary, 2002). However, the voicing distinction is perceived by a native as well non-native speaker of the language. In contrast, in Kannada, distinct voice-voiceless contrasts occur.

There was a need to assess whether children with hearing impairment, with different exposure to voicing, are able to perceive them similar to their normal hearing counterparts. There was also need to confirm whether children from two different language environments perceive voiced phonemes and voiceless phoneme equally well.

The present study was carried out with the aim of finding the effect of regional language on the perception of voicing of stop consonants in children with hearing impairment. In this study, the perceptions of voicing of stop consonants were evaluated in Kannada and Malayalam speaking children with hearing impairment.

Totally eighteen children with hearing impairment (10 Kannada speaking and 8 Malayalam speaking) were tested. All children had moderate to moderately-severe hearing loss.

The children were evaluated using nonsense consonants vowel (CV) and consonant-vowel-consonants (CVC) syllables. Stop (\p\, \t\, \th\, \k\, \b\, d\, \dh\, \g\), which are common in Kannada and Malayalam were selected. Each of these consonants was produced along with the vowels \a\, \i\ and \u\. Thus, a total of 72 stimuli, produced by a native Kannada speaker were recorded using the Adobe Audition software.

The test stimuli were presented to the better ear of each child in an unaided condition through headphones. The raw data obtained from the both group of children with hearing impairment were analyzed using Statistical Packages for Social Sciences (SPSS) software version 15. Descriptive statistics, 't' test and ANOVA were carried out to determine the perception of voicing. Besides studying the overall perception of voicing in the two language groups, perception of stop voicing in four place of articulation, three vowel environments and two positions were also analyzed.

The results of the study were:

- An overall significant difference between the two language groups was observed in their ability to perceive voice-voiceless stops.

- A significant difference occurred at all four places of articulation that were studied (bilabial, alveolar, retroflex and palatal) in voicing perception.
- No significant difference in voicing perception occurred across the four places of articulation in both language groups.
- A significant difference between language groups occurred at all three vowel combinations (\a\, \i\, \u\).
- No significant difference occurred across the three vowel combinations.
- At both initial and medial position, a significant difference between language groups occurred.
- No significant difference was observed between the initial and medial positions.

Implication of the study:

The findings of this study would be useful in providing rehabilitation to the children with hearing impairment. This study would be helpful to know the difference in perception of voicing contrasts between Kannada and Malayalam speaking children with hearing impairment. It would also provide information about the kind of voicing error seen in children with hearing impairment. Thus, it would be helpful in developing materials to teach voicing features in them.

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