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Perception of Phoneme Contrast in Children with Hearing Impairment in Telugu

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1.0. Introduction

Speech perception is the process of transforming a continuously changing acoustic signal into discrete linguistic units (Rvachew & Grawburg 2006).

Phoneme is the smallest linguistic unit of a language. Phoneme within a particular language helps in differentiating one word from another. Phoneme is merely a linguistic unit, which has no perceptual reality in speech perception. Phoneme perception is a form of auditory perception in which the listener and speaker distinguish among the sound contrasts in a language.

Auditory discrimination includes the ability to contrast sounds in environmental as well as the sounds and their pattern in language. Auditory discrimination is an ability to discriminate between the sounds at the articulatory, acoustics and other cognitive levels. Nicolosi, Harryman & Kreschech (1978) defined discrimination as the process of distinguishing among the speech sounds or words by differentiating them as same or different, while Wood (1971) defined auditory discrimination as the ability to discriminate between sounds of different frequency, intensity and pressure patterns; the ability to distinguish one speech from another (on the basis of these acoustic differences).

Development of Perception

Nittrouer & Burton (2005) showed that developmental course in speech perception occurs as a result of the child's experience with spoken language which produces a gradual accumulation of knowledge about the acoustic-phonetic cues that best represent the phonological units that are important in the ambient language system. The development of language-specific speech perception begins in infancy and continues into late childhood (Hazan & Barrett 2000). Phonemic perception plays crucial role in language processing and numerous behavioural studies have demonstrated similar capacities in infants and adults. Dehaene-Lambertz (1997) studied an event related potential by using phonemic discrimination tasks and compared them to results from the adults. The striking similarities observed both in behaviour and in evoked response potentials between the initial and mature stages suggest continuity in processing and neural structures.

Development of perception beyond the period of early childhood involves recognition of words. Word recognition is a complex process, involving the integration of both the sensory input, or acoustic-phonetic signal, and contextual information. The contextual information involves both pragmatic and general knowledge-based inferences regarding the gist of the incoming message and specific structural effects relating to the phonotactic, syntactic, and semantic restrictions characteristic to a language (Tyler & Frauenfelder 1987). On the whole, school-age children process continuous speech in an adult-like way, making use of context to aid in the interpretation of the acoustic signal. In several respects, children are different from adults; they appear to need more acoustic information before they commit themselves to a decision as to word identity, perhaps because so many words continue to be unfamiliar, at least up to the teens (Cole & Perfetti 1980; Walley & Metsala 1990).

Learning the Phonological System

Analysis of the developing speech of normal children suggests that learning the phonological system of the language is a rule governed process. Children tend to follow the same general sequence of development despite the fact that changes for acquisition vary greatly. Swoboda, Morse & Leavitt (1976) discovered that 2-months old not only discriminated /i/ and /e/ but they also discriminated vowel sounds that fell within the same vowel category but differed with respect to formant frequencies, suggesting that infants, like adults, also perceive vowels in a continuous manner (cited in Houston 2006). Trehub (1976) in Houston (2006) found that English-learning 1- to 4-montholds discriminated the vowel contrast /pa/ versus /ba/ and the consonantal contrast /ra/ versus /ʒa/, which is not linguistically distinctive in English. Unlike infants, English speaking adults often confused the /ra/ versus /ʒa/ contrast, suggesting that linguistic experience produces a loss of sensitivity to non-native contrasts.

Werker & Fennell (2003) conducted a study on 14 month-old infants using switch task. Following habituation to two familiar minimal pair object-label combinations (ball and doll) infants of 14 months looked longer to violation in the object label pairing (label “ball” paired with object “doll”) than to an appropriate pairing. These results using well known words are consistent with the pattern of data recently obtained by Swingley & Aslin (2002) in which it was found that infants of 14 months look longer to the correct object when accompanying well known word is spoken correctly rather than mispronounced. Katrin Stolten (2006) studied on effects of age of onset of L2 acquisition on categorical perception of the voicing contrast in Swedish word initial stops. Only a small minority of the late L2 learners perceived the voicing contrast in a way comparable to native-speaker categorization. The perceptual abilities of children older than twelve months has indicated that speech sound discrimination abilities continues to develop during preschool years and girls tend to perform better on discrimination tests as compared to boys (Barton 1976 & Edward 1974).

1.1. Studies Related to Phonemic Contrast Perception in Hearing Impaired Children

The relative effects of cochlear damage on the perception of various speech features are well established. It has been shown, in subjects with sensorineural hearing loss, supra-segmental features are perceived better than segmental features, vowels better than consonants, vowel height better than vowel place (front, back), word initial consonants better than word-final consonants, and consonant voicing and continuance better than consonant place (Erber 1972; Hack & Erber 1982; Martony et al. 1972; Pickett. et al. 1972; Risberg 1976; Walden & Montgomery 1975). It follows that an individual child may well be able to use hearing for access to certain speech features while requiring non-auditory means of access to others.

In preliminary observations of auditory vowel recognition by hearing-impaired children, Erber (1979) also found that severely hearing-impaired children tend to make two main types of confusions when identifying vowels acoustically. Some children confuse vowels having similar first formants and different second formants, that is, /i/ ↔ /u/. Others confuse vowels having similar first and second formants, or/i/ ↔ /I/.

These observations are similar to those reported by Pickett, Martin, Johnson, Smith, Daniel, Willis & Otis (1972). Profoundly hearing-impaired children seem to perceive vowels mainly on the basis of relative intensity and duration (in Hack & Erber 1982).

The speech encoding ability of eight persons with sensorineural hearing loss and three persons with normal hearing was studied in identification and discrimination paradigms. In the identification task a feature analysis of transmitted information for VC syllables was used to study encoding ability. Transmitted information was reduced (from normal children with compared hearing loss), indicating a loss of ability to encode consonants.

In the discrimination task, coding ability was studied by measuring reaction times for "same" and "different" decisions. The reaction time for individuals with impaired hearing was found to be significantly different from those subjects with normal hearing. The trend was faster for "same" than "different" reaction time among the normal subjects and faster for "different" than "same" reaction time among the hearing-impaired persons. The results are interpreted as indicating that the two groups of subjects used different processing modes in discriminating between pairs of phonemes (Reed 1975).

Erber (1972) examined the consonants /b, d, g, k, m, n, p, t/ were presented to normal-hearing, severely hearing-impaired, and profoundly deaf children through auditory, visual, and combined auditory-visual modalities and through lip-reading alone. The following groups of subjects were tested five children with normal hearing, five children with severe hearing impairments and five children with profound hearing loss taken from special school, all three groups were able to discriminate between the places of articulation (bilabial, alveolar, velar) but not within each place category. When they received acoustic information only, normal-hearing children recognized the consonants nearly perfectly, and severely hearing-impaired children distinguished accurately between voiceless plosives, voiced plosives, and nasal consonants. However, the scores of the profoundly deaf group were low, and they perceived even voicing and nasality cues unreliably. Although both the normal-hearing and the severely hearing-impaired groups achieved nearly perfect recognition scores through simultaneous auditory-visual reception, the performance of the profoundly deaf children was only slightly better than that which they demonstrated through lip-reading alone.

Jones & Studebaker (1974) studied performance of 23 hearing-impaired children on a closed-response, auditory speech discrimination test and on an open response, auditory speech discrimination test was compared to their performance on auditory tests of sensitivity, teacher evaluated categories, and other related subject data.

The three subtests that make up the OUCRT are (1) an initial-consonant subtest, (2) a final-consonant subtest, and (3) a medial-vowel subtest. The names of the subtests refer to the position of the phoneme which varies in the items of a closed response set. A comparison of the results of closed-response, auditory speech discrimination test and the open-response, auditory speech discrimination test indicates that the closed-response set test paradigm appears more productive for use with severely hearing-impaired subjects whose level of performance is low (but not 0%) on the open-response, auditory speech discrimination test. The closed-response test scores for this group are highly positively correlated to data dependent upon hearing function, whereas the open-response scores are not.

Analyses of the closed response set test results indicate that a closed-response set test paradigm can successfully demonstrate auditory speech discrimination error patterns on a subject group basis. The performance of these subjects on all three subtests of the OUCRT is positively correlated to the teacher evaluated "auditory speech understanding" results. Also, the two consonant subtest results are positively correlated with "overall understanding". These results suggest that the closed-response set test is a fair predictor of auditory speech understanding ability and overall understanding ability of severely hearing impaired subjects.

Hack & Erber (1982) investigated the vowels /i I e ɛ æ a u Λ ɜ n /. They were presented through auditory, visual, and combined auditory-visual modalities to hearing impaired children having well, intermediate, and poor auditory word recognition skills. The subjects were 18 hearing-impaired children whose speech perception abilities ranged widely. Their average hearing-threshold levels also covered a wide range (83-123 dB), participants were taken from special school setup. The stimuli included in the study were the 10 vowels presented in the bilabial context, /b/- (vowel) -/b/. The test tape of 55 items was shown three times.

When they received acoustic information only, children with good word-recognition skills confused neighbouring vowels (i.e., those having similar formant frequencies). Children with intermediate word-recognition skills demonstrated this same difficulty and confused front and back vowels. Children with poor word-recognition skills identified vowels mainly on the basis of temporal and intensity cues.

Through lip-reading alone, all three groups distinguished spread from rounded vowels but could not reliably identify vowels within the categories. The first two groups exhibited only moderate difficulty in identifying vowels audio visually. The third group, although showing a small amount of improvement over lip-reading alone, still experienced difficulty in identifying vowels through combined auditory and visual modes.

Boothroyd (1984) studied to find out how much of the acoustical information in amplified speech is accessible to children with varying degrees of sensorineural hearing loss. One hundred twenty students from the middle and upper schools of the special school for the Deaf were taken with different degree of hearing loss.

There were 61 boys and 59 girls aged 11-18 years, with a median age of 15 years. The perception of speech pattern contrasts was measured using a four-alternative, forced choice procedure. Four contrasts were evaluated: number of syllables per phrase, vowel nucleus, voicing and continuance of consonants, and place of articulation of consonants. The consonant contrasts were presented in both word-initial and word final positions. There were four trials in each of the four subtests, and the phonetic context of the test contrast was changed from trial to trial in order to reduce the likelihood that students would learn to respond to secondary acoustic cues. Four test forms were prepared, each response alternative serving as a stimulus on one test form context-varying, forced-choice tests of speech perception were presented, without feedback on performance, to orally trained subjects with better ear, three-frequency average hearing losses in the range 55-123 dB HL.

As expected, average performance fell with increasing hearing loss. The values of hearing loss at which scores fell to 50% (after correction for chance) were 75 dB HL for consonant place; 85 dB HL for initial consonant voicing; 90 dB HL for initial consonant continuance; 100 dB HL for vowel place (front-back); 105 dB HL for talker sex; 115 dB HL for syllabic pattern; and in excess of 115 dB HL for vowel height. Performance on the speech contrast tests was significantly correlated with the intelligibility of the subjects' own speech and with the open-set recognition of phonemes in monosyllabic words, even when pure-tone threshold was held constant.

Seewald, Ross, Giolas & Yonovitz (1985) evaluated the relationships between each of seven predictor variables the following seven variables were considered as possible predictors of the Primary Modality for Speech Perception (PMSP) a) Average Hearing Threshold Level b) Auditory Word Identification Performance c) Visual Word Identification Performance d) Auditory-Visual Word Identification Performance e) Age at which the use of amplification was initiated f) Age at which special education programming was initiated g) the primary mode of communication used in the classroom.

The four standard 25-item lists of the Word Intelligibility by Picture Identification (WIPI) test developed by Ross & Lerman (1971) were employed in the speech reception conditions. The 84 subjects were 15 normal-hearing and 69 hearing- impaired children (38 boys/46 girls) aged 7:5-14:8 (years: months). The 69 hearing-impaired children were selected from several self-contained and mainstream (regular school) educational settings. Of these, 32 were enrolled in educational programs in which total communication was employed, and the remaining 37 hearing-impaired children were selected from programs in which oral-aural communication was used exclusively. Six of the seven predictor variables were significantly correlated with the performance scores obtained within the auditory-visual conflict condition. Only pure-tone average hearing level and auditory word identification performance, however, made unique contributions toward predicting the degree to which audition or vision was used in the perception of the word stimuli.

They concluded that the relative use of audition or vision was almost completely related to their auditory capabilities as represented by the children's unaided threshold sensitivity and aided speech reception performance.

The perception of phonetic features is largely innate. Pre-lingual children are able to perceive all the phonetic contrasts of the world's languages, even those which do not exist in their linguistic environment (Vihman 1996 cited in Medina & Serniclaes (2005). Eimas (1974) empirically demonstrated this in a classic study, in which 1-month and 4-months olds exhibited superior discrimination of phoneme contrast which was from two different perceptual categories with the same categories.

Crandell, Siebein, Martin, Gold, Hassell, Lee, Abbott, Herr & Lehde (1998) examined the speech-perception abilities of children with normal hearing and children with hearing impairment in various classroom environments. Speech perception was assessed at different teacher-student distances via nonsense syllables, monosyllabic words, and sentences.

The acoustical environments varied as a function of reverberation time, early reverberation time, early to late energy ratios, loudness (or relative strength), speech transmission index, background noise levels, and signals to noise ratios. Normal-hearing populations included children, aged 5-15 years, who were progressing normally in school; learning-disabled children; children with central auditory processing deficits; articulatory- and or language-disordered children; children with developmental delays and or attention deficits; and children for whom English is a second language. Hearing-impaired populations consisted of children with minimal-to-severe degrees of bilateral and unilateral, sensorineural or conductive hearing loss. The speech perception abilities of an adult control group were also obtained.

The results from this investigation indicated the following: (1) each of the paediatric populations obtained poorer speech-perception scores that the adult control group; (2) children with sensorineural hearing loss obtained the poorest perception scores across the paediatric populations tested; (3) speech perception in typical classroom environments did not reach adult-like performance until the age of approximately 15 years; and (4) decreased teacher position significantly improved speech-perception scores in all acoustical environments.

Pittman & Stelmachowicz (2000) examined the perceptual-weighting strategies and performance audibility functions of 11 moderately hearing-impaired (Hearing Impairment) children, 11 age matched normal-hearing children, 11 moderately hearing impairment adults, and 11 normal hearing adults.

The purpose was to (a) determine the perceptual-weighting strategies of hearing impairment children relative to the other groups and (b) determine the audibility required by each group to achieve a criterion level of performance. Stimuli were 4 nonsense syllables (/us/, /uʃ/, /uf/, and /uθ/). Stimuli were 4 nonsense syllables (/us/, /uʃ/, /uf/, and /uθ/). The vowel, transition, and fricative segments of each nonsense syllable were identified along the temporal domain, and each segment was amplified randomly within each syllable during presentation.

Results showed that for /us/ and /uʃ/, all four groups heavily weighted the fricative segments during perception, whereas the vowel and transition segments received little or no weight. For /uf/, relatively low weights were given to each segment by all four groups. For /uθ/, the normal hearing children and adults weighted the transition segment more so than the vowel and fricative segments, whereas the hearing impairment children and adults weighted all three segments equally low. Performance-audibility functions of the fricative segments of /us/ and /uθ/ were constructed for each group.

In general, maximum performance for each group was reached at lower audibility levels for /s/ than for /ʃ/ and steeper functions were observed for the hearing impairment groups relative to the normal hearing groups. Results showed both hearing sensitivity and age effects. The hearing impairment listeners required lower levels of audibility than the normal hearing listeners to achieve similar levels of performance. Likewise, the adult listeners required lower levels of audibility than the children, although this difference was more substantial for the normal hearing listeners than for the hearing impairment listeners.

James, Rajput, Brown, Sriramanna, Brinton & Goswami (2005) conducted a short-term longitudinal study to investigate possible benefits of cochlear implant (CI) use on the development of phonological awareness in deaf children. Nineteen CI users, eleven profoundly deaf and ten severely deaf children served as subjects. A battery of tests was designed to investigate syllable, rhyme, and phoneme awareness. Syllable awareness in the CI users was equivalent to that of the severely deaf group, and rhyme and phoneme awareness was similar to that of the profoundly deaf children using hearing aids. CI use affords some benefit to the development of phonological awareness.

Linda, Spencer & Tomblin (2009) investigated the phonological processing skills of 29 children with pre-lingual profound hearing loss with 4 years of cochlear implant experience. Results were group matched with regard to word-reading ability and mother's educational level with the performance of 29 hearing children.

Results revealed that it is possible to obtain a valid measure of phonological processing (PP) skills in children using CIs. They could complete rhyming tasks and were able to complete sound-based tasks using standard test materials provided by a commercial test distributor. The CI children completed tasks measuring PP, but there were performance differences between the CI users and the hearing children. The process of learning phonological awareness (PA) for the children with CIs was characterized by a longer, more protracted learning phase than their counterparts with hearing.

Tests of phonological memory skills indicated that when the tasks were controlled for presentation method and response modality, there were no differences between the performance of children with CIs and their counterparts with hearing. Tests of rapid naming revealed that there were no differences between rapid letter and number naming between the two groups.

1.2. Need for the Study

Review of literature shows that the performances of contrastive system are likely to be different in hearing impaired children as compared to normal children. This difference in hearing impaired children may also vary depending on the rehabilitation prosthesis used by the children. There is scattered research on hearing impaired children using different prosthesis i.e. cochlear implants and hearing aids. The past researches have been confirmed to children with hearing impairment in general. Some of the studies have been confirmed to children using hearing aids (HA), very few studies with respect to children using cochlear implants (CI) and almost no studies in comparing the phonemic contrast perception ability between hearing impaired children using cochlear implants and hearing aids with reference to Telugu language. Research findings related to specific Indian language in children using CI and HA are needed to build up the much needed data base for pedagogical and clinical purposes.

1.3. Aim of the Study

The current study aimed at investigating and comparing the perception of phoneme contrast among children with hearing impairment using cochlear implants, children with hearing impairment using hearing aids and children with normal hearing in Telugu language.

1.4. Objectives of the Study

- To compare vowel and consonant contrast abilities between children with hearing impairment using cochlear implants and children with normal hearing in auditory-only condition.
- To compare vowel and consonant contrast abilities between children with hearing impairment using cochlear implants and children with normal hearing in audio-visual condition.
- To compare vowel and consonant contrast abilities between children with hearing impairment using hearing aids and children with normal hearing in auditory-only condition.
- To compare vowel and consonant contrast abilities between children with hearing impairment using hearing aids and children with normal hearing in audio-visual condition.
- To compare vowel and consonant contrast abilities between children with hearing impairment using cochlear implants and children with hearing impairment using hearing aids in auditory-only condition.
- To compare vowel and consonant contrast abilities between children with hearing impairment using cochlear implants and children with hearing impairment using hearing aids in audio-visual condition.

2.0. Methodology

2.1. Subjects

A total of 45 children (25 females and 20 males) with an age range of 8-12 years (mean age of 10 years) participated in the study. The subjects were divided into three groups consisting of 15 children in each group. Group I (NH): Consists of children with normal hearing, Group II (CI) consists of children with hearing impairment using cochlear implants and Group III (HA) consists of children with hearing impairment using hearing aids.

2.2. Stimuli Used

The items from the Telugu subtests of a tool for assessing input phonological processing in Telugu developed by Vasanta and Dodd (2007) were used as stimuli for the current study. The test consists of a total of 100 phonemic contrasts divided into four parts, such as 1) 20 vowel contrasts in Telugu 2) 30 consonantal contrasts in Telugu 3) 20 vowel contrasts in English and 4) 30 consonantal contrasts in English.

2.3. Procedure

Computer software was developed for the purpose of test administration. Auditory stimuli were constructed by recording each of the test item words as spoken by young female Telugu speaker. Recordings were performed using a unidirectional microphone in a sound treated room. Image files of each of the test items created by typing the words in Microsoft power point were used as visuals. The software was developed using visual basic.net 2003.

The children were seated comfortably and tested individually by the experimenter in a sound treated room with minimum distraction. Each test item pair was administered in ABX paradigm. Mode of presentation included 1) auditory-alone (A-alone) and 2) audio + visual (AV) presentations simultaneously; similar mode of presentation is used for both hearing aid users and cochlear implant users. Images of the written form of items A and B in each test pair appeared on the screen followed by the auditory presentations of the two items in order of appearance at 60dBSPL via loud speakers in 0' azimuth. Children were required to look at a pair of A and B items on the computer screen and had to decide whether the X item was either A or B. Most children indicated their preference by pointing to A or B on the screen after hearing the third 'X item' when tested through audiovisual mode. During auditory-alone presentation mode the children were asked to respond verbally after hearing the third 'X item'.

Examples of presentation of each item pair are shown below.

Contrast	Item A	Item B	X	Answer
/e-a/	pe:lu	pa:lu	pe:lu	1
/m-n/	mi:ru	ni:ru	ni:ru	2

The inter stimulus interval between the presentation of each of the items in the auditory-alone mode was 2 seconds. The inter stimulus interval between each pair of test item was 5 seconds. Stimuli once presented were not repeated. The presentation of words in each test item pair as displayed on the computer screen through the software.

2.4. Scoring

Each correct response was credited as 1 point and the wrong or incorrect response was scored as 0. Maximum possible score was 50 for Telugu subtest from the available Telugu –English subtests (a total of 100). All children in the Telugu speaking group were tested on only the phonemic contrasts in Telugu.

2.5. Statistical Analysis of data

The obtained data was analysed and compared by computing the mean percentage scores and standard deviations for each of the group. Inter group comparisons were done with appropriate statistical tools. One-Way Analysis of Variance was performed to compare the performance between groups in different conditions. In order to find out the significant difference between groups among data was further subjected to Least Significant difference (LSD).

3.0. Results

The present study aimed to compare the vowel and consonantal contrast perceptual abilities among children with normal hearing and children with hearing impairment using cochlear implants and hearing aids in Telugu. The perceptual ability of above mentioned children was assessed in auditory-alone and audiovisual conditions.

3.1. Comparison of Vowel Contrast Perception between Auditory-alone and Audio-visual conditions

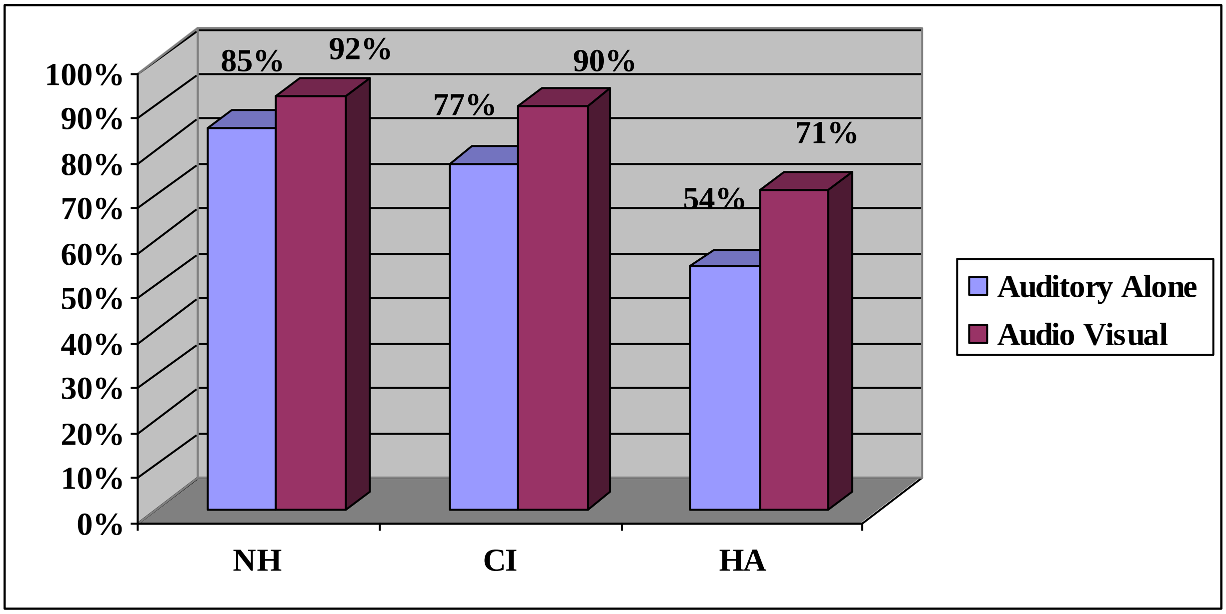

Figure 1 Mean percentage for Vowel Contrast in Auditory-alone and Audio-visual condition for three groups

Figure 1 shows comparison of mean percentage scores for perception of vowel contrast in auditory alone and audiovisual condition obtained by children with normal hearing (NH), children with hearing impairment using cochlear implant (CI) and children with hearing impairment using hearing aids (HA). The mean percentage scores were 85%, 77% and 54% in auditory alone and 92%, 90% and 71% in audiovisual condition for children with normal hearing (NH), children with cochlear implant (CI) and children with hearing aids (HA) respectively. Children with normal hearing (NH group) obtained higher mean scores than children with hearing impairment (CI and HA group) in both conditions. Among hearing impaired group children with CI obtained higher mean scores than children with HA. Children in the hearing impaired group (both CI and HA) obtained higher scores in audiovisual condition than in auditory alone condition.

When the data was further subjected to statistical analysis to find out significant difference between groups, it revealed that there was a statistically significant difference between NH group VS CI group, CI group VS HA group and NH group VS HA group in auditory-alone condition. In Audio-visual condition there was a statistically significant difference between CI and HA groups for vowel contrast perception. However, there was no statistically significant difference between NH group and CI group in audio-visual condition. There was a statistically significant difference in mean % scores in hearing impaired group (both CI and HA groups) between auditory-alone and audio-visual condition. However, there was no statistically significant difference for NH group between auditory alone and audiovisual conditions.

3.2. Comparison of Consonant Contrast Perception between Auditory-alone and Audio-Visual Conditions

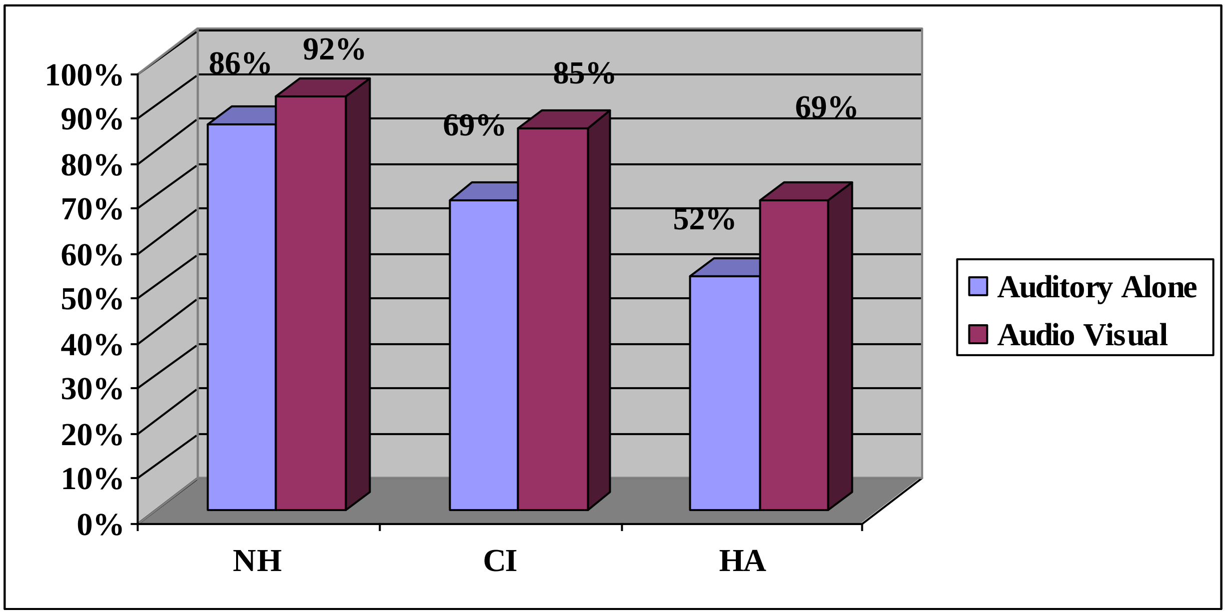

Figure 2 Mean percentages for Consonant Contrast in Auditory-alone and Audio-visual condition for three groups

Figure 2 shows comparison of mean percentage scores for perception of consonant contrast in auditory alone and audiovisual condition obtained by children with normal hearing (NH), children with hearing impairment using cochlear implant (CI) and children with hearing impairment using hearing aids (HA). The mean percentage scores were 86%, 69% and 52% in auditory alone and 92%, 85% and 69% in audiovisual condition for children with normal hearing (NH), children with cochlear implant (CI) and children with hearing aids (HA) respectively. Children with normal hearing (NH group) obtained higher mean scores than children with hearing impairment (CI and HA group) in both conditions for consonant contrast perception. Among hearing impaired group children with CI obtained higher mean scores than children with HA. Children in the hearing impaired group (both CI and HA) obtained higher scores in audiovisual condition than in auditory alone condition.

When the data was further subjected to statistical analysis to find out significant difference between groups, it revealed that there was a statistically significant difference between NH group VS CI group, CI group VS HA group and NH group VS HA group in auditory-alone condition. In Audio-visual condition there was a statistically significant difference between CI and HA groups for consonant contrast perception. However, there was no statistically significant difference between NH group and CI group in audio-visual condition. There was a statistically significant difference in mean % scores in hearing impaired group (both CI and HA groups) between auditory-alone and audio-visual condition. However, there was no statistically significant difference for NH group between auditory alone and audiovisual conditions.

4.0. Discussion

The present study aimed to compare the vowel and consonantal contrast perceptual ability among NH, CI and HA groups in Telugu under auditory-alone and audiovisual conditions. The results revealed that NH group performed better than hearing impaired group (both CI and HA) in both vowel and consonant perception abilities and was found to be statistically significant. This was observed in both auditory-alone and auditory-visual conditions.

Although, NH group performed better in audio-visual condition than in auditory-alone condition, there was no statistically significant difference between two conditions. The NH group obtained similar results for both vowel and consonant contrast perception. These findings are in accordance with the findings of Reed (1975), Erber (1972), Seewald, Ross, Giolas & Yonovitz (1985), Crandell, Siebein, Martin, Gold, Hassell, Lee, Abbott, Herr & Lehde (1998), Pittman & Stelmachowicz (2000).

Among hearing impaired children CI group performed better than HA group in both vowel and consonant contrast perception abilities. This was observed in both auditory-alone and auditory-visual conditions. The children with hearing impairment (both CI and HA groups) performed better in audio-visual than auditory-alone condition. These findings are in accordance with the findings of James, Rajput, Brown, Sriramanna & Goswami 2005).

It was also observed that CI group using cochlear implants performed almost similar to normal children in vowel contrast under audio-visual mode. The superior performance by CI group as compared HA group could be attributed to the reason that children using cochlear implant simultaneously perceive the voicing feature and are less dependent on the visual cues when compared to children with hearing impairment using hearing aids (Geers 2003).

However, the hearing impaired group (both CI and HA) obtained better scores for vowel contrast perception than consonant contrast. Vowels are produced without obstruction in the airflow. Perception of vowels is because they are voiced and relatively high in intensity. Vocal tract is relatively open for them producing prominent resonance for vowels. Vowels are more accessible to auditory analysis by virtue of their longer duration and may hold longer duration in the auditory memory. Consonants are produced with the obstruction in the airflow. They vary by the place of articulation, manner of articulation and voicing. Consonant being less accessible to auditory analysis due to their brevity and relatively low intensity and held briefly in auditory memory (Stevens 2006).

Piossant et al (2006) concluded that following the implantation, hearing impaired children rely on some extent on auditory feedback from the implant to control durational aspects. The NH group obtained similar results for both vowel and consonant contrast perception.

5.0. Summary and Conclusion

The present study aimed to compare the vowel and consonantal contrast perceptual abilities among children with normal hearing and children with hearing impairment using cochlear implants and hearing aids in Telugu. The perceptual ability of above mentioned children was assessed in auditory-alone and audiovisual conditions. On average children with normal hearing performed better than children with hearing impairment. All the children performed better for vowel contrast discrimination than for consonant contrast. Among the children with hearing impairment, children using cochlear implants perform better than children with hearing aids. Children using cochlear implants performed almost similar to normal children in vowel contrast under audio-visual mode. Children with normal hearing performed almost similar in both audio-visual and auditory-only conditions, whereas children with hearing impairment performed better in audio-visual than auditory-alone condition.

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