LANGUAGE IN INDIA
Strength for Today and Bright Hope for Tomorrow
Volume 11: 4 April 2011
ISSN 1930-2940

Perception of Phoneme Contrast in Noise in Children with Normal Hearing and Cochlear Implant: A Comparative Study

Winnie Alex, M. Sc. (Audiology Speech Language Pathology) Student
S. B. Rathna Kumar, M. Sc. (Speech & Hearing), PhD (Applied Linguistics) Scholar
G. Yamini Sindhura, B. Sc. (Audiology Speech Language Pathology) Student
S. G. R. Prakash, M.Sc. (Speech & Hearing) Ph.D. (Applied Linguistics)

Introduction

Speech perception is the process of transforming a continuously changing acoustic signal into discrete linguistic units (Rvachew & Grawburg 2006). The development of language-specific speech perception begins in infancy and continues into late childhood (Hazan & Barrett 2000). Phoneme perception is a form of auditory perception in which the listener and speaker distinguish among the sound contrasts in a language. Nicolosi, Harryman & Kreschech (1978) defined discrimination as the process of distinguishing among the speech sounds or words by differentiating them as same or different.

The relative effects of cochlear damage on the perception of various speech features are well established. It has been shown that subjects with sensorineural hearing loss perceive suprasegmental features 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 (Risberg 1976; Hack & Erber 1982). Raja, Kumar, Prakash & Reddy (2010) studied the perception of vowel contrasts and consonant contrasts in normal hearing, children with hearing impairment using cochlear implants and hearing aids. They found that children using cochlear implant perform better than children using hearing aids and the mean scores of children with cochlear implants were almost equal to normal hearing group.

Review of literature shows that children with cochlear implants performed better than children with hearing aids. Although children with cochlear implants performed better, it is expected that perception of phoneme contrast ability would be lessened in the presence of background noise. There is a dearth in research studying the phoneme contrast perception in cochlear implanted children compared with normal children in the presence of background noise especially with reference to Telugu language. Research findings related to specific Indian language are needed to build up the much needed data base for pedagogical and clinical purposes.

Aim of the study

The current study aims at investigating and comparing the phoneme contrast ability between children with hearing impairment using cochlear implants and children with normal hearing in the presence of background noise in Telugu language.

Method

Subjects

A total of 30 children with an age range of 8-12 years (mean age of 10.6 years) participated in the study. The subjects were divided into two groups; each group consisted of 15 children. Group I: Consisted of children with normal hearing (NH), while Group II included children with bilateral severe to profound sensorineural hearing loss using cochlear implants. All the children in group II had a minimum experience of 3 years with cochlear implant. Three of the children were with bimodal stimulation (i.e. using hearing aid in the non-implanted ear along with cochlear implant in the other ear).

Participants' selection criterion

> **Group I (NH):** The children with normal hearing were chosen for the study as control group. The age range was between 8 - 12 years. These participants had no history of hearing loss, middle ear pathology or no disorder with speech and hearing ability. They had 20 dB HL or better pure-tone average (PTA) bilaterally. They were having normal intelligent quotient and no illness on the day of testing. They were native speakers of Telugu and could read Telugu words.
>
> **Group II (CI):** The children with bilateral severe-profound sensorineural hearing loss were chosen for the study as experimental group. All the children were using CI 24 RE (CA) with freedom Speech Processor. Children with an age range of 8-12 years were selected and were Telugu native speakers. They were having normal intelligent quotient and no illness on the day of testing.

Stimuli Used

The tool for assessing input phonological processing in Telugu developed by Vasanta & Dodd (2007) was 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. The items from the Telugu subtests were used as stimuli for the study. The contrasts included in the test encompass the following features in Telugu language: vowel height, vowel place, vowel duration, consonant place, consonant manner and consonant voicing.

Most of the test items for vowel and consonantal contrasts included bisyllabic words. For the vowel contrasts, each test item made use of simple syllable structures, where as the consonantal contrasts were signalled using both simple and complex syllable structures i.e. geminates or clusters. All items were meaningful words justifying the testing for discrimination of each pair of items.

Procedure

Instrumentation

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.

Test Administration

The children were seated comfortably and tested individually by the experimenter in a sound treated room with minimum distraction. Auditory stimuli were recorded in quiet and +10 dB SNR condition by a young female speaker and were presented through loud speakers. Each test item pair was administered in ABX paradigm. The stimulus was presented through audio-visual mode; similar mode of presentation was used for both normal hearing group and cochlear implant group. 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 60 dB SPL 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.

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 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.

Scoring

Total score for vowel and consonant contrast perception were 20 and 30 respectively. Thus a maximum possible score was 50 for combined vowel and consonant contrast perception. Each correct response was credited as 1 point and the wrong or incorrect response was scored as 0.

Statistical Analysis of data

The obtained data was analysed and compared by computing the mean scores and standard deviations for each of the group. Inter group comparisons were done with appropriate statistical tools. The data was subjected to independent comparison t-test in order to find out significant difference between the groups and paired comparison t-test to find out significant difference between conditions (Quiet and +10 dB SNR) in same group.

Results

The present study aimed to compare the vowel and consonantal contrast perceptual ability in Telugu among children with normal hearing and children using cochlear implants in the presence of background noise. The perceptual ability of above mentioned children was assessed in audiovisual conditions. The results are discussed below:

I Perception of Vowel Contrast:

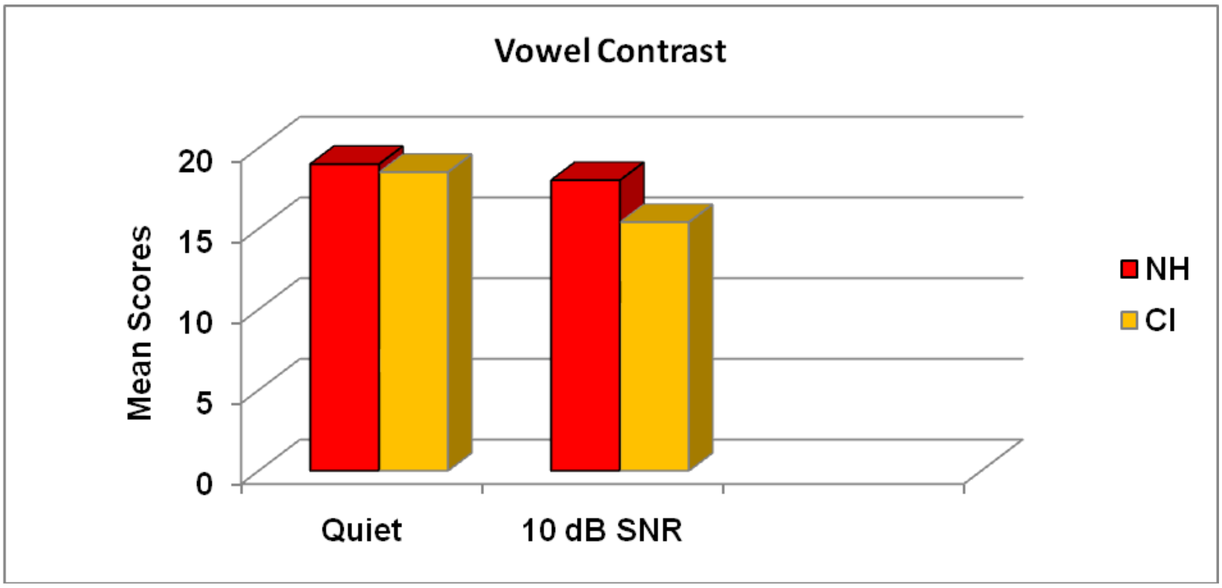

Figure 1: Comparison of mean scores of vowel contrast perception between quiet and noise for two groups

As shown in Figure 1, the NH group obtained an overall mean score of 19 (out of 20) as compared to the mean score of 18.5 (out of 20) obtained by CI group in quiet condition for vowel contrast.There was no significant difference found for vowel contrast perception between NH and CI groups in quiet condition ($p>0.05$). The NH group obtained an overall mean score of 18 (out of 20) as compared to the mean score of 15.4 (out of 20) obtained by CI group in +10 dB SNR condition for vowel contrast.There was a statistically significant difference ($p<0.05$) found for vowel contrast perception between NH and CI groups in noise.

II Perception of Consonant Contrast:

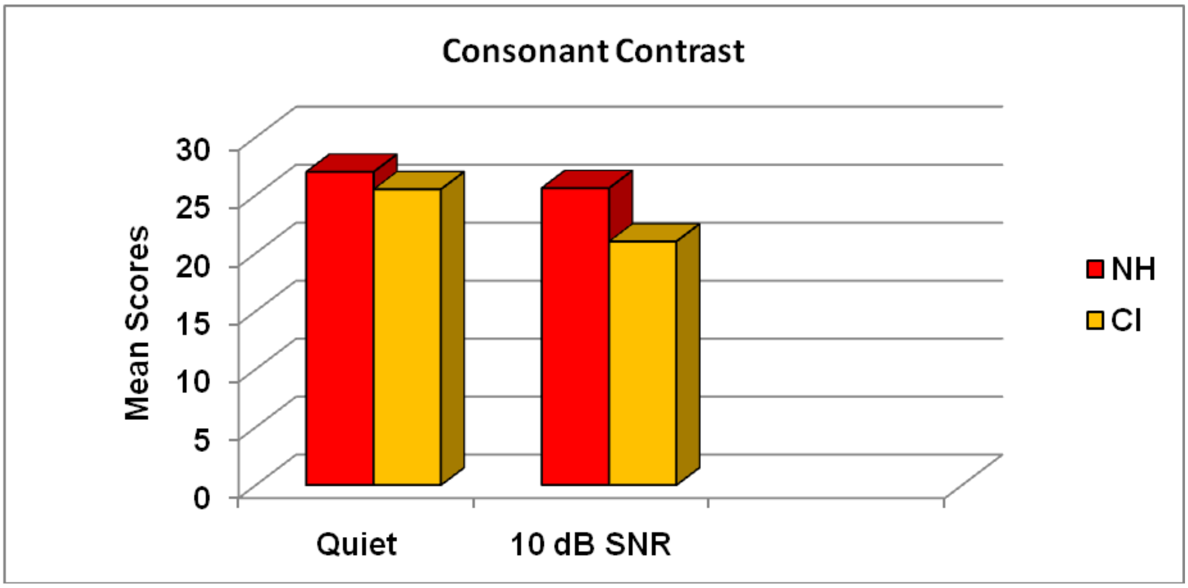

Figure 2: Comparison of mean scores of consonant contrast perception between quiet and noise for two groups

As shown in Figure 2, the NH group obtained an overall mean score of 27 (out of 30) as compared to the mean score of 25.5 (out of 30) obtained by CI group in quiet condition.There was no significant difference found for consonant contrast perception between NH and CI groups in quiet condition. Whereas, the NH group obtained an overall mean score of 25,6 (out of 30) as compared to the mean score of 21 (out of 30) obtained by CI group in +10 dB SNR condition.There was a statistically significant differece ($p<0.05$) found for consonant contrast perception between NH and CI groups in noise.

III Overall mean scores (Vowel & Consonant Contrasts):

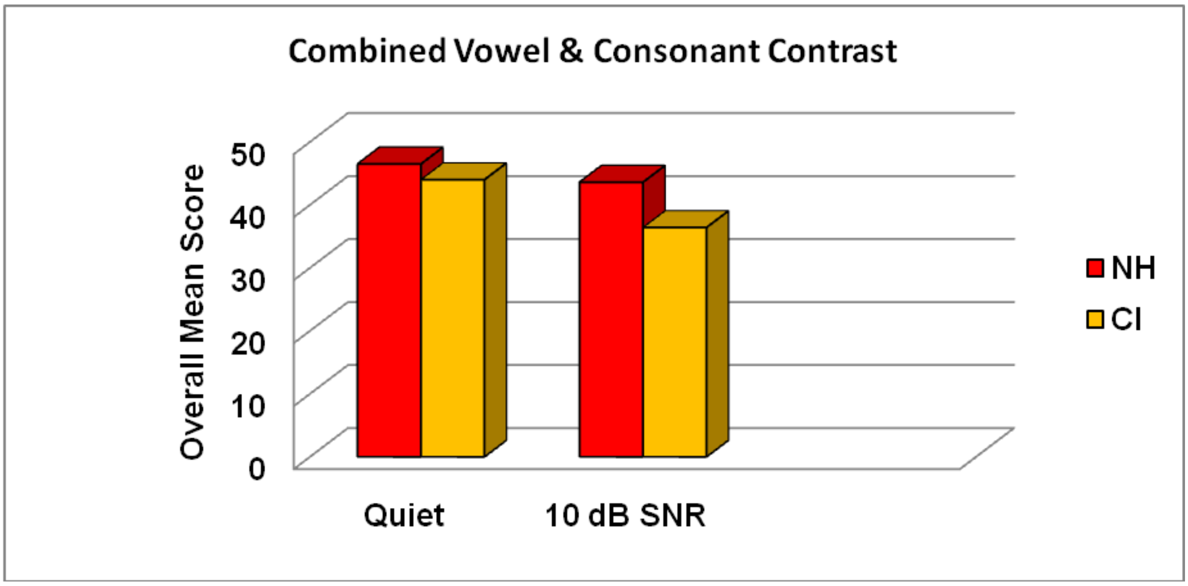

Figure 3: Comparison of overall mean scores between two groups in quiet and noise

As shown in Figure 3, the NH group obtained an overall mean score of 46.5 (out of 50) as compared to a mean score of 44.5 (out of 50) obtained by CI group in quiet condition. There was no statistically significant difference found between two groups in quiet. Whereas, the NH group obtained a mean score of 43.6 (out of 50) as compared to a mean score of 36.4 (out of 50) by CI group in +10 dB SNR condition. There was a statistically significant difference ($p<0.05$) between two groups in noise.

Discussion

The present study aimed to compare the vowel and consonant contrast perceptual ability among normal hearing group and children using cochlear implants in Telugu under noise and quiet conditions. Overall both normal hearing children and children with cochlear implants have performed similar in both vowel and consonant contrasts perception in quiet. Significant advances over the years in cochlear implant technology, speech coding strategies and surgical techniques have resulted in substantial improvements in the auditory-only speech understanding abilities of cochlear implant recipients (Dowel 2005). Moreover, children using cochlear implants simultaneously perceive the voicing feature and are less dependent on the visual cues when compared to children using hearing aids with similar degree hearing losses (Geers 2003).

However, the same CI group performed poor in noisy situation as compared to NH group. This could be attributed to the reason that the actual amount of information that can be transmitted to CI users is severely limited by a host of additional physical and physiological factors such as the electrode-nerve interface, nerve survival, and brain plasticity. These limitations result in 6 to 10 functional channels and poor temporal and spectral cues, compared with most normal-hearing listeners, in a typical cochlear implant user (Kong, Cruz, Jones & Zeng 2004; Nascimento & Bevilaqua 2005). The same signal processing and physical and physiological limitations also contribute to the problem facing most current cochlear users who can achieve a high level of speech recognition in quiet but suffer greatly in noise particularly when the noise is temporarily fluctuating, such as competing voice (Nelson, Jin, Carney 2003; Stickney, Zeng, Litovsky & Assmann 2004).

Another reason could be that binaural fitting have been traditionally applied to hearing aids, monaural stimulation has commonly pertained to cochlear implants. Children who receive monaural cochlear implants will not get the benefit of binaural hearing. Providing binaural hearing is a vital component of aural rehabilitation as it uses auditory inputs from both ears and helps to localize sounds and to understand speech better in adverse listening situations such as presence of noise (Ching 2005). Most of the subjects from CI group participated in the study were monaural cochlear implant users (only 3 children were using bimodal stimulation).

Conclusion

Cochlear implants have presented significant advances for the past decades relative to speech codification strategies, but current devices still do not restore normal perception of speech, especially in adverse situations such as presence of noise. The findings of the current study highlight the variation in phoneme contrast perception in children using cochlear implant in the presence of background noise. Cochlear implantees performed poorer in the presence of noise due to lack of binaural advantage and limited capacity to extract speech from noise. Thus the findings of the present study depict the importance of binaural hearing in speech perception in noise. Hence, it can be concluded that bilateral cochlear implantation or bimodal fitting with cochlear implant may provide a better phoneme contrast perception in noise.

Acknowledgement

Authors would like to thank Prof. R. Rangasayee Director AYJNIHH for his support. A very special 'thank you' is expressed to the participants and their parents in this study. The authors would also like to thank all those who reviewed or commented on this paper during presentation in 43rd ISHACON.

This paper was presented under Poster Presentation in Speech in 43rd Indian Speech and Hearing Association Conference 2011 (43rd ISHACON 2011) held at Kolkata in January 2011.

References

Ching T.Y.C. (2005): The evidence calls for making binaural-bimodal fittings routine. *The Hearing Journal*, 58, 32-41.

Dowel, R. (2005): Evaluating cochlear implant candidacy: recent developments. *The Hearing Journal*, 58(11), 9-23

Geers, A.E. (2003): Predictors of Reading Skill Development in Children with Early Cochlear Implantation. *Ear and Hearing*, 24,595-685

Hazan, V., & Barrett, S. (2000): The development of phonemic categorization in children aged 6 to 12. *Journal of Phonetics*; 28: 377-396

Kong, Y.Y., Cruz, R., Jones, J.A., & Zeng, F. G. (2004): Music perception with temporal cues in acoustic and electric hearing. *Ear and Hearing*, 25,173-185

Nascimento, L.T., & Bevilaqua, M.C. (2005): Evaluation of speech perception in noise in cochlear implanted adults. *Brazilian Journal of Otorhinolaringology,* 71 (4), 432-438.

Nelson, P. B., Jin, S.H., Carney, A.E., & Nelson, D.A. (2003): Understanding speech in modulated interference: Cochlear implanted children in comparison with normal hearing children. *Journal of the Acoustical Society of America*, 113(2): 961-8.

Nicolosi, L., Harryman, & Kreschech, J.S. (1978): Terminology of communication disorders, Baltimore, Williams and Wilkins.

Raja, S., Kumar, S.B.R., Prakash, S.G.R., & Reddy, M.S. (2010): Perception of Phoneme Contrast in Children with Hearing Impairment in Telugu. *Language in India*, 10(12), 129-145.

Risberg, A. (1976): Diagnostic rhyme test for speech audiometry with severely hard of hearing and profoundly deaf children. In *Proceedings at Speech Transmission Laboratory QPSB (Karolinska Technical Institute, Stockholm)*, 2-3, 40-58.

Rvachew, S., & Grawburg, M. (2006): Correlates of phonological awareness in Pre-schoolers with speech sound disorders. *Journal of Speech Language and Hearing Research*, *49*(1), 74-87.

Vasanta, D., & Dodd, B. (2007): Perceptual factors in phonological disorders: A tool for assessing input phonological processing in Telugu-English bilinguals. *Osmania Papers in Linguistics*, 33: 55-72.

===

Winnie Alex, M. Sc (Audiology Speech Language Pathology) Student
Ali Yavar Jung National Institute for the Hearing Handicapped
Southern Regional Centre
Secunderabad 500 009 Andhra Pradesh, INDIA
Winniewins552@gmail.com

S. B. Rathna Kumar, M. Sc (Speech & Hearing), PhD (Applied Linguistics) Scholar
Ali Yavar Jung National Institute for the Hearing Handicapped
Southern Regional Centre
Secunderabad 500 009 Andhra Pradesh, INDIA
sarathna@yahoo.co.in

G. Yamini Sindhura, B. Sc (Audiology Speech Language Pathology) student
Ali Yavar Jung National Institute for the Hearing Handicapped
Southern Regional Centre
Secunderabad 500 009 Andhra Pradesh, INDIA
yaminisindhura@yahoo.com

S. G. R. Prakash, M. Sc (Speech & Hearing) PhD (Applied Linguistics)
Ali Yavar Jung National Institute for the Hearing Handicapped
Southern Regional Centre
Secunderabad 500 009 Andhra Pradesh, INDIA
Praksh_nihh@rediffmail.com