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Effects of Noise Level and Azimuth on Speech Perception Ability of Children with Hearing Impairment Using Cochlear Implant and Hearing AIDS

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Abstract
Speech perception is a specialized aspect of a general human ability, the ability to seek and organize speech sound to central auditory system. Speech perception ability plays significant role for classroom learning special for children with hearing impairment. Daily classroom activities and background noises in schools create unfavorable context for children with HI in speech perception. Teachers in regular classroom act as moving sound source for children with hearing loss. Therefore current study aimed to evaluates the effect of noise level and direction (azimuth) on speech perception ability of children with HI using HA and CI. 50 subjects (25 HA users 25 CI users age and gender matched) were enrolled in the study with mean age range of CI subjects was 8.13 and HI subjects was 7.65. Test was performed in an acoustically sound treated two room setup. Better ear/implanted side speaker was set for giving speech input at a constant level of 60 dB whereas other side speaker used for delivering broadband noise (BBN) at different SNR(i.e. 15dB,10dB,5dB,0dB). Further to check effect of direction 0, 45, 90, 180 azimuth PB word (speech) delivered and corresponding speech perception score were recorded. Results indicate that both the group shown effect of noise on speech perception ability, increasing SNR better speech perception. Whereas higher speech perception scores seen when speech delivered at 0 azimuth and least score obtained at 180 azimuths. Statistical't' tail test results showed significant difference between groups and higher score obtained by CI group. Research study suggests that both the groups adversely effected by noise on speech perception score. Therefore conclusion of study that currently used HA & CI electro-acoustic technologies are not efficient to overcome effect of noise on speech perception ability, therefore the strong need felt in the advancement of speech processing technology in HA and CI.
Key Words: *Speech Perception, Cochlear Implant Users, Hearing aid users, Noise, Azimuth*

Introduction

In the human auditory physiological system, middle ear conduct mechanical sound energy that creates a traveling wave on the Basilar Membrane causes the hair cells of the inner ear to be stimulated. The activation of inner and outer hair cells produces neural activation discharge of auditory nerve fibers. (Katz et al. 2005). Processing of sound involves the peripheral and central auditory system for all listeners, including cochlear implant users and hearing aids users. Understanding speech requires both anatomical and functional integrity of the peripheral and central auditory system and an acoustically appropriate communication context. Generally noise is present in most communication situations, which may decrease the probability of acoustic information being available. Noises create several problematic issues in children with hearing impairment when speech and noise compete at the same time. The possible reasons for these are masking effect, loss of binaural integration, which increases the signal noise ratio at 3 dB or more, the difficulties in the temporal and frequency resolution; the reduction of the dynamic range of hearing and the effect of masking the low frequencies energy on the medium and high frequencies threshold (i.e. upward spread of masking). Hearing aids and Cochlear implantation are most frequent used treatment option for person with hearing impairment (Katz et .al. 2005). Over the years, many research study reported that the speech recognition abilities changes after fitment of cochlear implant and hearing aids significantly .(Bilger, 1977; Blamey et.al 1990; Eddington, 1980; Schindler et. al. 1993; Skinner et al., 1991; Staller et al., 1997; Tyler et. al. 1989; Wilson et. al. 1991). Cochlear implant user group as outcome shows wide variability in the speech perception ability after fitment. Main variability factors are subject characteristics, psychophysical measures, device characteristics, and neurophysiologic differences. There are various anatomical specific factors that might account for variability in performance across CI users are the extent of neural survival (Jyung, Miller, & Cannon, 1989; Shepherd, Clark, & Black, 1983; Walsh & Leake-Jones, 1982), properties of the auditory nerve i.e. the ability to recover from a refractory state (Brown, Abbas, Borland, & Bertschy, 1996; Brown, Abbas, & Gantz, 1990; Stypulkowski & van den Honert, 1984), the influence of sensory deprivation on Neurophysiological development cortical plasticity (Leake, Hradek, Rebscher, & Snyder, 1991; Lousteau, 1987; Trune, 1982), spatial and temporal resolution abilities (Shannon, 1983; Zeng & Shannon, 1994), and the integrity of the central auditory pathways (Kraus et al., 1993b; Micco et al., 1995; Oviatt & Kileny, 1991; Stypulkowski, van den Honert, & Krivstad, 1986). Children with hearing impairment may develop open-set speech recognition in quiet listening situations when they are early identified and fitment with CI/ HA. This performance significantly deteriorated in the presence of noise Geers, 2004; Geers, Brenner, & Davidson, 2003; Osberger, Zimmerman-Phillips, & Koch, 2002; Waltzman, Cohen, Green, & Roland, 2002. Davies et. al. 2005 found that children with HI shown significant difference in the speech perception score in noisy situation and quiet environment i.e. 20 to 30 % reductions in speech perception score. Neumann et. al. 1983 repoted that when background noise (+6 S/N) the children with normal hearing achieved word recognition scores of approximately 70% as compared to 50% for students with hearing impairment .

Similarly advancement in hearing aids technology such as Directional microphones , acoustic filter , multi -channeled amplification have proven to be the most effective, solution for speech understanding in noise . (Bentler, 2005; Eisenberg et.al. 2001; Litovsky et al., 2004; Schafer et.al. 2003). Recent year's number integration of student with HI in to regular school has got increased due to advancement of hearing aids and cochlear implant technology. Young children with HL will encounter noise in all aspects of their lives, including school, where there is a constant level of noise in the classroom ranging from 30 to 70 dBA (Arnold et. al. 1999; Bess et.al. 1984; Knecht ET. al. 2002). In Indian scenario children with HL often transition into larger, fully mainstreamed classrooms was oral – aural mode of teaching mainly used. In India although constitutional acts like (PWD 1995) that promote appropriate education with least restrictive barrier free environment for children with HI. Regular classrooms with excessive noise and poor signal-to-noise ratios (SNRs) will not allow for a suitable listening environment for classroom learning. Regular school teachers many time move during the lecture therefore teachers in regular classroom act as moving sound source for children with hearing loss. Direction of sound source in classroom is also equally important factor in term of speech perception. Therefore current study entailed to check speech perception score under different noise level and effect of direction/ azimuth of sound source on children using Hearing Aids and cochlear implant.

Aim and objectives:

To assess speech perception ability of (CI) & (HA) user under different noise level (BBN)

To compare speech perception score under different noise level between CI and Hearing Aids user

To assess speech perception ability of CI and HA users when speech presented under different azimuth.

To compare speech perception ability of CI and HA users when speech presented under different azimuth.

Methods

Test condition: Two rooms setup was used with standard of ANSI. S.1: 1991 (specification for maximum permissible ambient noise pressure level in an audiometric room)

Instrument used are:

Audiometer: GSI 61(dual channel audiometer)

Speaker: Two calibrated speaker were used and calibration was done by Sound Level Meter. (2250 Bruel & Kjaer).Instructions: CI & HA user was instructed that few words will be presented; they must listen to it carefully and repeat those words. 25 cochlear implant users and 25 Hearing aid users where enrolled in the study with mean age range of CI subjects was 8.13 and HI subjects were 7.65. Among HA group 5 subjects were using semi digital hearing aid in both the ears and remaining all were using digital hearing aids in both the ears. Among CI group, all the subjects were implanted CI in the right ear and were using digital hearing aid in other ear, except 2 subjects who were implanted CI in the left ear. Usage of hearing aid and cochlear implant was around 10-12 hrs per day in both the groups. Mean hearing age of subjects with HA are 3.4 years and subjects with CI are 3.3 years. In HA group, subjects are taking continuous therapy for around 2-3 years whereas in CI group subjects are taking continuous therapy for around 3-4 yrs. oral aural mode of teaching were used by teachers and therapist in school .

Procedure: Test was performed in a two room noise setup. A dual channel diagnostic audiometer GSI-61, with calibrated sound source was used. Client was seated in the centre between two speakers at a distance of 1 meter away from the sound source. Right side speaker was set for giving speech input at a constant level of 60 dB whereas left speaker was set to broadband noise and the noise level was varying from 45 dB to 60 dB. Further four different azimuths speech input speaker were used 45, 0, 90, and 180. Four sets of standard phonetically balanced (PB) word list were used. 40 words were presented to each CI and HA user with speech at constant 60 dB and noise at 45 dB initially and then gradually noise level is increased up to 60 dB. After presenting 40 PB words at each noise level, WRS (word recognition score) was calculated at each azimuth on different noise levels.

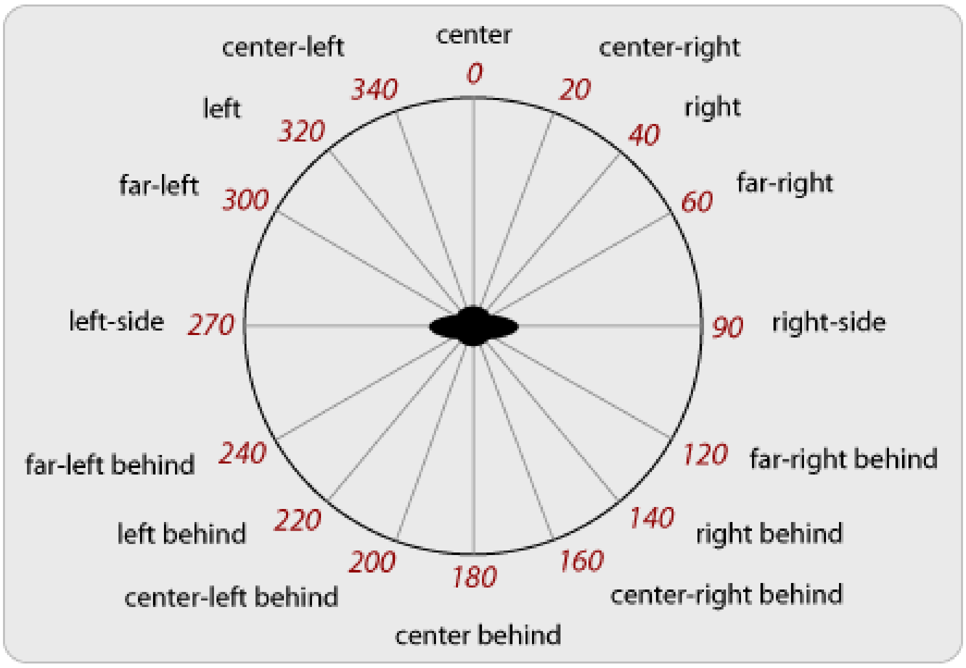

Figure 1 showing the different azimuth used in the study (i. e 0, 45 .90, 180 degree)

Data were collected from both the group and means and SD calculated using SPSS 16. Test of normal distribution skewness and kurtosis were within the normal limits suggesting that data in form of normal distribution. Further to check statistical significance difference between means two tail Independent sample t tail test was used (i .e CI group and HI Group) .

Objective one: To compare speech perception score under different noise level between Cochlear implant and Hearing Aids user.

GROUP		N	MEANS	STD	STD ERROR MEAN
15 SNR	CI	25	72.7273	9.25301	2.78989
	HA	25	61.9000	21.30441	6.73705
10 SNR	CI	25	67.0909	7.48939	2.25813
	HA	25	56.0000	20.92314	6.61648
5 SNR	CI	25	61.8182	7.83349	2.36189
	HA	25	50.0000	23.57023	7.45356
0 SNR	CI	25	58.0909	7.91776	2.38729
	HA	25	44.0000	22.70585	7.18022

Table showing descriptive value of means score obtained at different SNR in CI and HA groups

T test for equality of means						
	T	Sig (2 tailed)	Mean difference	Std error difference	95% confidence interval of the difference	
					Lower	upper
15 SNR	1.537	0.0023	10.82727	7.04608	-3.92034	25.57489
10 SNR	1.649	0.043	11.09091	6.72491	-2.98449	25.16631
5 SNR	1.574	0.045	11.81818	7.51032	-3.90111	27.53747
0 SNR	1.937	0.032	14.09091	7.27469	-1.13519	29.31701

Table Showing 't' tail test result of CI and HA users at different noise level (p value 0.05 level)

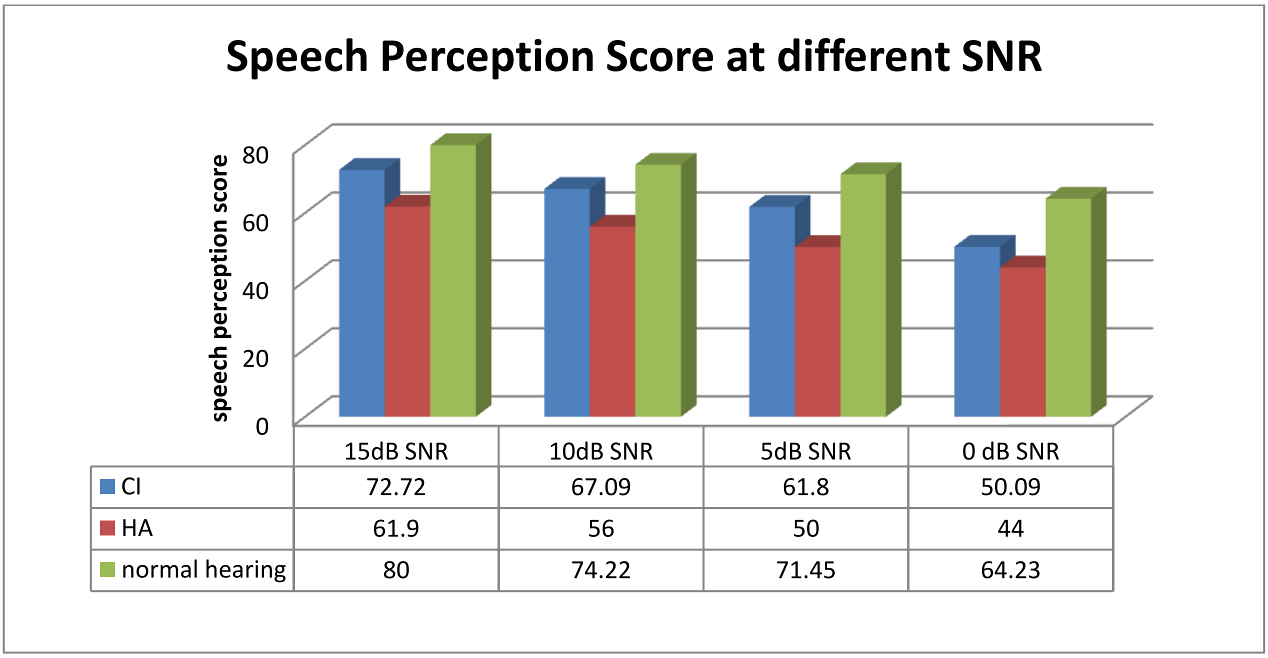

Table showing effect of different noise level on speech perception score

Effect of noise levels and speech perception score negatively related when the noise level increases it is effecting speech perception score more in both the test groups (HA users and CI users). While comparing between this two groups CI users obtained higher speech perception ability than hearing aids users. This could be due to different factors such as speech therapy, early intervention, speech processing strategies etc.

Objective 2: To Compare Speech Perception Score When Noise Present At Different Azimuth Between Ci And Hearing Aids User.

		N	MEANS	STD	STD ERROR MEAN
0	CI	25	73.1818	9.81650	2.95979
	HA	25	63.5000	18.11230	5.72761
45	CI	25	72.7273	9.31763	2.80937
	HA	25	64.5000	21.53163	6.80890
90	CI	25	72.7273	9.25301	2.78989
	HA	25	61.9000	21.30441	6.73705
180	CI	25	70.4545	9.34199	2.81672
	HA	25	58.8000	22.60678	7.14889

Table showing descriptive value of means score obtained at different Azimuth in CI and HA groups

‘t’ tail test of equality						
Azimuth	t	Sig (2 tailed)	Mean difference	Std error difference	95% confidence interval of the difference	
					lower	Upper
0	1.543	0.139	9.68182	6.27286	-3.44742	22.81106
45	1.156	0.262	8.22727	7.11674	-6.66824	23.12278
90	1.537	0.141	10.82727	7.04608	-3.92034	25.57489
180	1.572	0.133	11.65455	7.41519	-3.86563	27.17473

Table showing‘t’ tail test result of CI and HA users at different Azimuth (p value 0.05 level)

At 45 azimuth speech perception ability in CI user is ranging from 72.7 to 53.09 whereas in 180 azimuth speech perceptions ability gets much affected in CI user. It ranges from 70.45 to 52.03. At 45 azimuth, speech perception ability in HA user ranges from 64.5 to 48 whereas when it is 180 azimuths it ranges from 58 to 40. Therefore when person speaks from front (0 azimuths) even under noise significant higher score seen compared to 180 azimuths.

Discussion

Finding of study suggests that hearing aids user shown significant lower speech perception score compared to CI group. Hearing aids users perceive speech in a fragmented manner due to the acoustic filter effect that occurs when their hearing aids do not amplify the complete speech signal into their comfortable listening range. Hearing aids amplification range restricted up to only 4000Hz as many formant transition occurs at high frequency which missed out by HA users (Flexer, 1999; Gordon-Salant, 1985). Speech spectrum contains all the frequency range which has its clinical significance in term of speech perception. Children with hearing impairment using HA shows typical audiometric configuration i.e. more degree of hearing loss at high frequencies which effect perception of important high frequency consonant sounds like s, sh, Ch , f, th (Estabrooks 2005). HA users do not hear the complete speech signal (wide frequency signals) and it is at lesser intensity speech signal even more vulnerable to degradation by the distance or poor room acoustics. Hearing aids amplify both background noise and teacher's voices thus limiting the benefits of HA in typical classroom listening environments.(Nabalek, Donahue & Letowski, 1986).

Whereas CI speech-processing attempts to replace the function of the inner ear cochlea that play role in transduction of mechanical vibration in to bio-electrical form. Parameters like the rate of stimulation, number of channels to be activated, and mode of stimulation, electrical pulse width etc play important role in transmission of electrical signal in the auditory nerve. Specific values of these parameters along all available electrodes define "map" for an individual cochlear implantee. Cochlear implant users speech perception outcomes may differ based on the above mentioned parameters and type of strategy he/she is using. (Pasanisi et al., 2002; Psarros et al., 2002; Skinner et al., 2002a, b; Plant et al., 2002). Crouch (1997) reported that children receiving CIs obtain sufficient linguistic benefit from these devices to permit them to be fully participating members of the hearing community. Similar results noted by Tyler et al 1987 that the higher effectiveness of CIs on speech perception and speech production. However, several research have demonstrated that children receiving CIs show improvements in speech perception and speech production skills (Fryauf-Bertschy, Tyler, Kelsay, & Gantz, 1992; Geers & Toby, 1992; Osberger et al., 1991; Tobey, Geers, & Brenner, 1994; Tye-Murray & Kirk, 1993). The positive results from the above studies of speech perception and production strongly suggest that CIs provide an improved sensory experience of spoken language. Therefore children with CI show gains in the acquisition of higher levels of language involving the lexicon, grammar, and discourse. Present research finding also reporting that Cochlear implant group showing higher speech perception score comparing HA user. CI users showing better biological processes in the auditory system which delimiting noise effect and helps to better speech sounds representation in the central auditory system. Hence auditory system of CI groups better able to filter out non meaning full event such as noise.

In classroom activities movement done by teacher acts as moving sound source i.e. sound source at different direction also effects speech perception ability. Results of the study shows higher speech perception score seen at 0 azimuth i.e. Results study indicates that person speak from front (0 azimuth) highest recognition ability seen. Therefore if teacher in regular class deliver lecture from front will help to HI children to understand speech maximally . Current study finding suggesting that teacher should be at zero azimuths at which children with hearing impairment not only get maximum better auditory speech perception also can assess visual cues. There are various study supports that children with hearing impaired able to do better speech perception when both modalities used (e.g., McGrath and Summerfield, 1985).

Summary & Conclusion

As both the group shown deteriorations in speech perception ability under noise .Hearing aids and cochlear implants both devices technology need to improve strategies of converting acoustic energy into other form. Microphone, internal digitalization circuit, speech processor of CI, transmitting coil, internal/external electrode etc component further advancement required. Difficulty perceiving speech under typically noisy classroom conditions has spurred the use of signal-to-noise enhancing technology for children utilizing hearing aids or cochlear implants.

Hence current study finding recommend school to provide as much as quite environment (15dB Signal to noise ratio) for children with hearing impaired using HA and CI. Regardless of the advancements in hearing aids and cochlear implants, digital sound processing or programmable technology cannot overcome the effects of background noise on speech perception. It appears that presentation of amplified speech within the critical listening environment is an important key factor in addition to an S/N of at least +15. Not only noise but the direction of the sound source also gets affected (i.e. front and back) plays a significant role in terms of speech perception. When the sound source is in the front speech perception is good whereas when it is at 180 azimuth speech perceptions gets affected adversely. As the implications of the findings of this research are considered for practical application, individual student characteristics and the specific acoustic characteristics of the learning environment need to be considered carefully when deciding which type of educational amplification technology should be provided. With the advent of early identification of hearing loss in infants and appropriate early intervention services, it is probable that greater numbers of students with hearing loss will enter inclusive educational settings with normal, or near normal, educational skills. These students will require educational amplification technology and standard acoustic classroom setup. In inclusion set up teacher should deliver lecture from front and at highest possible signal to noise ratio considering special need of children with hearing loss.

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