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A comparative study on auditory perception of environmental sounds by normal hearing & unilateral cochlear implant children

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Abstract
Accurate identification of environmental sounds may lead to better speech perception because properties of sound coming from the environment contain lot of information. It also provides comprehensive assessment of sensory input in early stage of life. The present study was aimed to compare the recognition of environmental-sounds by normal hearing children and children using unilateral cochlear implants in auditory-alone condition. 30 subjects participated in this study which was divided into two groups. Group I consist of 15 normal hearing children with age range of 3-5 years. Group II consists of 15 children using unilateral cochlear implants with an auditory experience of minimum 3 years of daily implant use. 20 environmental sounds belonging to different categories such as animal, human, vehicle, mechanical & nature served as the test tool. The findings of this study revealed that Children using cochlear implant obtained lower mean percentage values compared to children with normal hearing. Environmental sound perception ability in cochlear implant children was poorer than normal hearing children. The ability to perceive environmental sounds are often unappreciated and largely unexplored.

Keywords: cochlear implant (CI), normal hearing (NH), non-linguistic sound (NLS), threshold

1. Introduction

Auditory perception of environmental sounds plays a significant role in daily living activities in human life. Environmental sound perception is a key component in children to acquire auditory skills and language behavior. Therefore, it is important for cochlear implant (CI) children. It is crucial for children to identify the accurate source of environmental sounds which has many important benefits. Furthermore, auditory perception of environmental sounds may help to improve speech perception. Normal hearing (NH) listener's exhibit accurate recognition of all environmental sounds with or without little difficulty and can describe the comprehensive information about the sound sources. On the other hand, it may be difficult to perceive environmental sounds for CI children who receive distorted sensory input, and after a period of time, may need to relearn common environmental sounds. In the beginning of implant development, several environmental sound perception tests were conducted to assess the effectiveness of cochlear implant. Furthermore, a child of environmental sound performance has some association with their speech perception scores [1]. Children perceive environmental sounds in daily routine which contain a great variety of acoustic signals. They exhibit broad abilities to recognize and monitor events in their environment; these skills of children are often unrewarding and, with the exclusion of speech, largely undiscovered [2]. Environmental sounds are non-musical, non-linguistic & complex sounds. They are dynamic which convey the meaningful information of the real surroundings. These environmental sounds are produced by real events & are meaningful in that particular situation [3].

Perception of environmental sounds can provide information about the things which is happening around the child, the direction of sound source, the place of sound source and origin of the sound source [4]. This information helps children to avoid danger and it increases the awareness of the sound sources in the neighboring world. These nonlinguistic sounds (NLS) allow individuals, both adults and children, to feel safe, as well as connected to the environment that surrounds them [5]. These nonlinguistic sounds (NLS) enable children to shape their auditory environment through incidental learning. A child ability to recognize environmental sounds may help him to understand speech, as a series of event in his life from sounds to meaningful sounds to symbols [6]. Children with severe to profound hearing loss are incapable to hear the environmental sounds and therefore, many important auditory connections are not made. Even in adults with post lingual hearing loss, it is possible to regain hearing through amplification or cochlear implantation, but it has been shown to be difficult for them to identify nonlinguistic sounds out of context [7, 8]. Generally, CI children express a variety of enthusiasm when they identify the accurate source of environmental sounds after the implantation. However, it may difficult for CI children to relearn environmental sounds after a period of deafness [9, 10].

1.1 Aim of the study
The present study was aimed to compare the performance in perception of environmental sounds by normal hearing children and children using unilateral cochlear implants in auditory alone condition.

2. Material and Methods
A total number of 30 subjects participated in this study which was divided into two groups. Group I consist of 15 normal hearing children with age range of 3-5 years (mean=3.53, SD=0.74). Group II consists of 15 children using unilateral cochlear implants (Cochlear Nucleus) with an auditory experience of minimum 3 years of daily implant use (mean=3.8, SD=0.76). All the subjects before selection underwent free field audiometry with warble tone at octave frequencies between 250 Hz to 4 KHz and their hearing threshold were 35 dB HL or better. Children with CI were attending auditory verbal therapy at least for 5 days in a week for 40 minutes duration in each day. Another ear of the CI children was profound hearing loss and does not use hearing aid. A written consent was taken from their parents or care taker.

2.1 Stimuli and procedure
Auditory perception of environmental sounds was assessed using a developed set of sound track (Shafiro, 2008) [4]. It include 20 environmental sounds belonging to different categories such as animal, human, vehicle, mechanical & nature served as the test tool. Administration of the test battery was carried out in a sound proof room with ambient noise level within permissible limits (ANSI 3.1-1991). The test stimuli were stored in a personal laptop (Compaq CQ 60) and were connected to a diagnostic audiometer (Intra-acoustic AC-40). Stimuli delivered from the laptop were calibrated by using a sound level meter (B & K digital SLM) kept one meter away from the loud speaker (230V active speakers). The intensity level of the output stimulus was 70dB SPL, delivered with a single speaker positioned from the distance of one meter to the implanted ear at an angle of 45° to the subject mid-line on the same side as the implant to avoid obstructing the space between the ear and the loud speaker. The order of presentation was randomized. It was ensured that the children were attentive prior to the presentation of the stimuli. The children were given a familiarization trial prior to the testing. The participants' task was to listen to the audio stimuli delivered through the loud speakers and respond orally or pointing to one of the four response cards placed in front of them that best represented the stimuli.

The response obtained from the subjects was scored & rated as correct-3, partially correct-2 and incorrect response-1. A score of 3 suggested that the child was able to imitate the stimulus and pointed to the correct source as soon as the stimulus was heard. Score of 2 indicated that the child was able to imitate the stimulus but could not identify the source & a score of 1 indicated that the child was neither able to imitate the stimulus nor able to correctly identify the source. The responses of each participant were tabulated. The responses obtained from the subjects were statistically analyzed.

3. Results
The overall mean percentage values in identification of environmental sounds by children with Normal Hearing (NH) and Cochlear Implant (CI) were 96.5 & 87.7 respectively.

Table 1: Mean, % of Mean, SD, t-value of overall scores in identification of environmental sounds by children with NH & CI

	Group	N	Mean	%	SD	T-value	Significance
Environmental sounds	NH	15	57.9	96.5	1.83	4.883	.000
	CI	15	52.6	87.7	3.81		

Children using cochlear implant (CI) obtained lower mean percentage values compared to children with normal hearing. The mean score were subjected to independent sample T- test to see the significant difference between groups. The result revealed that there is statistically significant difference ($p < 0.05$) between the groups (t- value =4.883, sig=0.000).

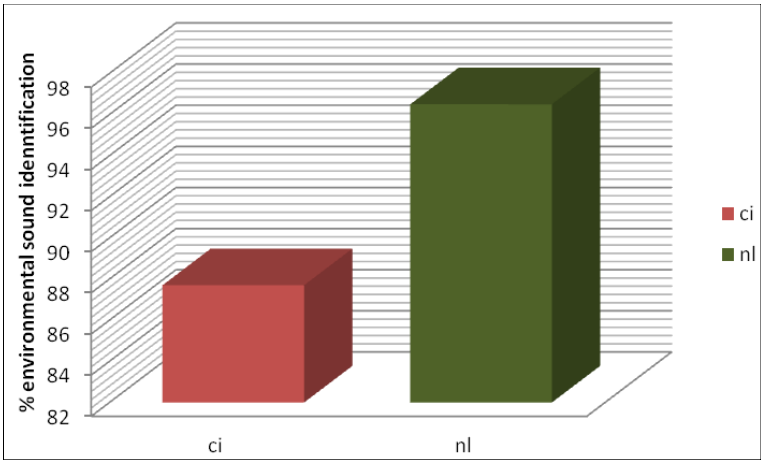

Fig 1: Mean % for overall scores of environmental sound identified by cochlear implant (CI) and normal hearing subjects.

4. Discussion
Results of this study revealed that auditory perception of environmental sound in CI were poorer than normal hearing children. These differences between the CI and normal hearing might be because of a large number of neuronal activities occurring at peripheral and central level of brain in processing of sound. One of the major factor could be absence of the effects of binaural hearing in the CI which attributed to

head-shadow, binaural redundancy and binaural squelch. The same type of result was noticed by Janna Arnephy *et al* (2008). In present study it was noticed that normal hearing children can identify most of the environmental sounds with little difficulty and can provide accurate information about the sound sources. This was also reported by Shafiro *et al*., 2008 [4]. Auditory perception of speech and environmental sounds has an association among them. Cochlear implant children show sensory limitations imposed by implant during processing of signal and due to deficiencies in the auditory periphery. This inherent limitation of signal processing by implant along with other stimulus and subject specific factors might have played significant role in the poor identification of environmental sounds as compared to that of NH. The child's ability to process quick frequency changes plays a significant role in the perception of speech as well as in environmental sounds. Both temporal as well as spectral cues are well perceived by the NH group whereas CI children's exhibit limited sound spectral resolution and degrades temporal fine structure. These reasons could have been contributed to the difference found in environmental sound identification between the two groups.

5. Conclusion

Speech perception are with a cochlear implant is very well studied, and it is accepted that many beneficiaries attain significant open-set speech recognition (Dowell *et al*., 2004, Hamzavi *et al*., 2003). Survey research has shown that both pre-lingual and post-lingual deafened cochlear implant (CI) candidates describe the perception of environmental sounds as one of the desired benefits of a cochlear implant (Pollack *et al*., 2001; Zhao *et al*., 1997) and also as an important component of daily living. Even though communication researchers have concentrated mainly on speech and, to a lesser extent music, there is an increasing appreciation of the significance of other meaningful sounds in the ironic acoustic texture of everyday life. Latest CI research has revealed that environmental sound training can provide important improvement in speech perception and auditory sound perception (Loebach & Pisoni, 2008). Regardless of numerous positive and valuable features of environmental sound perception, there is limited information about auditory perception of environmental sounds, relevant factors, and associated perceptual processes in normal and hearing-impaired individuals. The ability to perceive environmental sounds are often unappreciated and largely unexplored (Handel, 1995; McAdams, 1993).

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