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Original Research Paper

Audiology

THE EFFECTS OF TRAINING ON LISTENING TASK IN PRE-LINGUAL COCHLEAR IMPLANT CHILDREN

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ABSTRACT In the last few years, cochlear implant has been a technological boon to the people with profound hearing loss especially among children who are congenitally deaf. Undoubtedly, it is one of the major life changing interventions for such profoundly deaf people till date. However, CI recipient children struggle in spoken language learning and speech intelligibility. It has been witnessed that CI recipient children have delays in language learning as they have deficits in cognitive and auditory processing. It stands to reason that auditory training would improve the auditory skills which would support language development and learning. The present study has attempted to study the effects of providing training to Cochlear Implanted children who were congenitally born deaf and determine the possible outcome of effects of training on listening tasks in Prelingual CI children. A group of 15 children who underwent Cochlear Implantation were considered for the study. The children who attended aural habilitation training during the initial six months were studied. The children were given training on 10 tasks that consisted of different activities. The performances of the children were compared with the Categories of Auditory Perception (CAP) Score rating scale after six months of training and one month post-training. Paired sample t-test was conducted to test the hypothesis and mean scores were considered. The results showed that the majority of the children showed improvement in their speech intelligibility and auditory performance. Future studies with larger samples are required for the generalizability of the study findings.

KEYWORDS : Cochlear implantation, speech intelligibility, cognitive and auditory processing, Prelingual Cochlear Implant, Categories of Auditory Perception (CAP) Score, aural habilitation training, auditory training, spoken language learning

1. INTRODUCTION

Cochlear implants (CI) have aided many prelingually deafened children with hearing ability. Advancements made in the CI technology have not only helped the children who are congenitally born deaf with hearing ability but also with speech perception. It is evident that CI recipient children struggle in spoken language unlike normal hearing (NH) peers as they have deficits in both cognitive and auditory skills underlying the language development. In this regard, literature on cognitive and auditory training indicates an improvement in their cognitive and auditory functioning post-training. Thus, it stands to reason that training would improve the cognitive and auditory skills which would support language development and learning. (Ingvalson & Wong, 2013). Word-learning training has shown to be effective on rapid word learning abilities in children with CI in a study conducted by Lund & Schuele, 2014. Working memory training is also provided to the children with CI for improving their language skills and memory who are congenitally born deaf. After the completion of the training, children have shown significant improvement in the nonverbal and verbal working memory and sentence-repetition skills. This sort of training may prove to be beneficial for some language skills and memory in CI recipient children (Kronenberger et al., 2011).Audiologic rehabilitation training is provided to the child so that his or her speech and hearing improves. This auditory-visual training aids children with CI as it improves their speech understanding and quality of life (Baungaard et al., 2019).Speech intelligibility improvement is one of the primary goals of CI in prelingually deafened paediatric population which can be defined as the degree of acoustical signal that is understood by the listener (Hassan et al., 2013).

With this view, the present study is aimed at analysing the effects of training on listening tasks in Prelingual Cochlear Implant children. The present review also aims to study the effects of providing training to Cochlear Implanted children who were congenitally born deaf and assess the training of children on multiple aspects once they start hearing post-switch-on of the Cochlear Implant system.

2. AIMS AND OBJECTIVES

The present study aims to analyse the effects of training on listening tasks in Prelingual Cochlear Implant children.

This section will include the objectives to be studied in the paper which are illustrated as:

- To find out the effects of providing training to Cochlear Implanted children who were congenitally born deaf
- To assess the training of children on multiple aspects once they start hearing post-switch-on of the Cochlear Implant system
- To determine the possible outcome of effects of training on listening tasks in Prelingual Cochlear Implant children

3. Literature review

3.1 Aspects of prelingual cochlear implant

Cochlear implantation has provided better results in children with hearing loss in cases where the disability severity makes hearing aids incapable of providing effective hearing and auditory information. Cochlear implants stimulates the cochlear nerve fibres directly enabling better discrimination and perception of speech, environmental sounds and alerts (Bittencourt et al., 2012).With the advent of CI, it has shown promising results in the alleviation of impact of profound prelingual hearing loss. As duration of deafness and age increases, effectiveness of CI starts becoming less predictable, however, CI could be extremely effective in many cases (Campbell et al., 2014). CI is an universally accepted paradigm for treatment of deafness for individuals of 12 months or older. The efficacy of CI in hearing rehabilitation relies on the acoustic sound converted to a series of electrical impulses stimulating the auditory nerve through electrodes implanted surgically in the cochlea. It has been observed that young people undergoing CI who are prelingually deaf have shown excellent outcomes (Zeitler et al., 2012).

CI are the treatments of choice for patients having sensorineural hearing loss for whom conventional hearing aids do not work. Being congenital or not, prelingual hearing loss in children and receiving CI during the first year of their life had significant outcomes so far as compared to CI later in life (Souza et al., 2011). The use of CI contributes to the development of auditory perception that favours acquisition of linguistic mechanisms that are related to communication skills that might have a positive effect on the other developmental areas. When compared to the normative process of language acquisition, the results showed that the children had patterns of linguistic skills that are beyond their chronological age indicating that they are developing receptive and expressive oral language skills which was a major outcome of this study (Scarabello et al., 2020). CI in early-deafened individuals whether adults or adolescents is not advised in all cases because of poor expected outcomes. This review showed that late CI in early-deafened individuals resulted in improved audio-visual speech perception, open-set speech perception and quality of life related to hearing in majority of research done in this regard (Debruyne et al., 2017; Debruyne et al., 2020).

3.2 Effects of providing training to Cochlear Implanted children

In a study conducted by Roman et al (2016), a program training was developed called "Sounds in Hands" which utilised an interactive playful-based environment allowing manipulation of sounds in real-time in many auditory tasks. The results are note-worthy as it pinpointed the auditory deficits in CI children and helped to gather a better understanding of the connections between speech perception and auditory skills that in turn allowed more efficient rehabilitative programs.

Auditory training is a habilitation intervention based on sound and aimed at improving the speech of an individual as well as hearing skill through listening exercises of various kinds. Auditory training teaches the brain in making sense of the sound contrasts through variation of stimuli and repetition along with effective feedback. In this way, the listener learns to habitually distinguish between the sound contrasts. (Rayes et al., 2019).

Children with CIs have a characteristic deficit in pitch processing that results in impairments in understanding of emotional intention in spoken language and in music perception. Music therapy improves accuracy of the children with CI in rhythm perception and melodic contour and could be an effective supplementary technique for auditory rehabilitation following CI in children (Good et al., 2017).

3.3 Training of children on listening task in Prelingual Cochlear Implant system

Zakirullah et.al (2008) conducted a prospective study to evaluate the development of language and auditory perception skills in children following CI over a period of twelve months. EARS protocol was used that comprised of listening progress, pictured words, closed set bi-syllabic words, closed set sentences, Language specific sentences, Open set monosyllabic words (OSM), auditory screening procedure and questionnaires of meaningful use of speech scale (MUSS) and meaning auditory integration scale (MAIS) with testing intervals. The improvement rates in the linguistic and auditory development were found to be most impressive after a year of device use.

Researches have shown that deafened adults pre and post lingual may benefit from the aural rehabilitation intensive programs that emphasise on auditory training and strategies that enhance understanding. Schraer-Joiner et al 2012 conducted a study, PHASE I that examined speech and music perception of CI users and resulting web-based music training protocol. There has been improved speech and music perception among the children with CI along with music appreciation.The training was conducted at four levels that aligned with the levels of discrimination, auditory development, comprehension and identification.

Ingvalson et al (2014) conducted a study to observe that working memory and phonological skills are important for the development of spoken language. Children with CI who received phonological-working memory training showed significant gains in composite and expressive language scores. This indicates that if training is provided to improve the working memory and phonological skills in children with CI, it leads to improved performance in language.

4. METHODOLOGY

This study followed a quantitative approach in analysing the effects of providing training to the CI children who were born congenitally deaf. A descriptive research design is followed. This research design is appropriate for the present research as it helps to study the effects of providing training to the children with CI.

A primary data collection method was chosen wherein original data has been collected being commonly used in descriptive research design as employed. Data was collected from 15 children who underwent cochlear implantation and attended aural habilitation during the initial six months. The children were given training on 10 tasks that consisted of different activities. The performance of the children were compared with Categories of Auditory Perception (CAP) Score Revised rating scale after one month post training and after six months of training.

The data was analysed by comparing the performance of the children in the tasks with the Categories of Auditory Perception (CAP) Score Revised rating scale after six months of training and one month post-training. The data analysis tools such as SPSS and descriptive analysis have been used for the analysis of the collected data. Paired sample t-test was conducted for testing hypotheses and instead of utilising median scores, mean scores have been used.

The study followed the below hypothesis:

H0: the median CAP Score between CAP Score at the end of 6 months of therapy and CAP Score after one month of therapy is 6

H1: the median CAP Score CAP Score at the end of 6 months of therapy is lesser than CAP Score after one month of therapy.

For the present study, ethical approval was taken from the Ethical Committee and informed consent was collected from the parents of the study participants.

5. RESULTS

Task I was the identification of environmental sounds such as clapping, bell ring, whistle blowing, mother's voice and father's voice. The children had to identify the common environmental sounds. From figure 1, it is evident that 100% of the children learned the activities of clapping, bell ringing and mother's voice. 86.7% of children responded to environmental sound, whistle blowing and 93.3% of children responded to their father's voice.

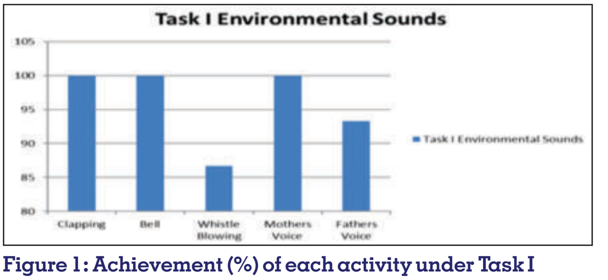

Figure 1: Achievement (%) of each activity under Task I

Task II was conditioned play responses such as presenting a toy, placing ring over a cone, placing balls in a basket, Gentle clap of baby's hands, flashing of light and pressing of a button wherein the children had to perform these particular activities attending to an auditory stimulus. From figure 2, it is evident that 86.7% of the children completed the activities; presenting a toy, placing a ring over a cone, placing balls in a basket and gentle clapping of the baby's hands. About 73.3% of children completed the task of flashing of light and about 60% of the children completed the task of pressing a button effectively.

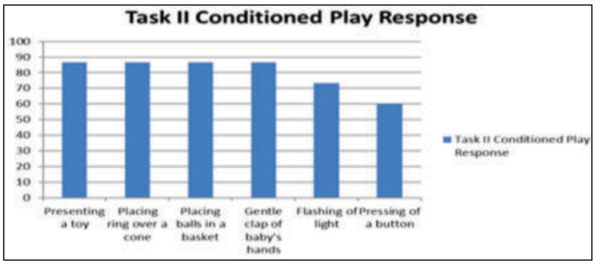

Figure 2 : Achievement (%) of each activity under task II

Task III was performed which was related to Ling's Six Sound wherein the child had to detect and produce the particular ling sounds. From figure 3, it is evident that about 93.3% of the children detected the sound "Ah " for aeroplane, "Ee " for rat, "Mm" for ice cream and "Sh" for sheep. Whereas, about 86.7% of the children detected the sound "Oo" for owl and 66.7% of them detected the sound "Ss" for snake.

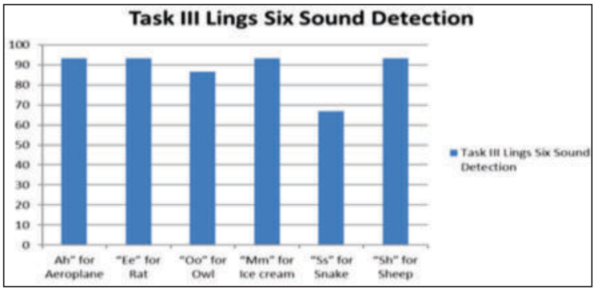

Figure 3 : Achievement (%) of each activity under task III

Task IV was increased vowel vocalisation wherein the children were asked to vocalise the given sounds effectively. Based on the four activities, figure 4 shows that 80% of the children vocalised the sound "Aa", "Ee" successfully and 60% of them vocalised the sound "Uu" and "Mm" successfully.

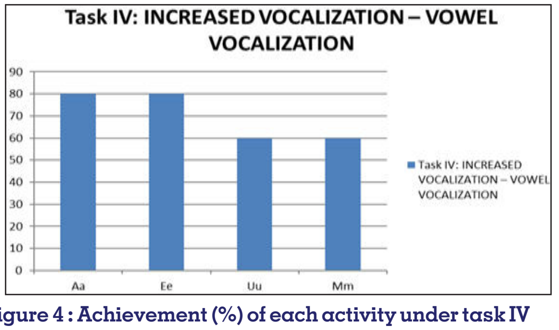

Figure 4 : Achievement (%) of each activity under task IV

Task V was to attend to name call. From figure 5, it is evident that about 86.7% of the children responded to name call successfully.

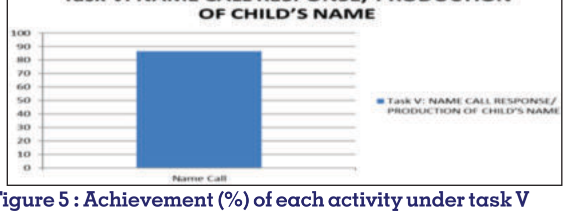

Figure 5 : Achievement (%) of each activity under task V

Task VI was performed wherein the children had to respond to different stimuli and identify whether the tasks are same or different which comprised of seven activities. The results of the task VI as depicted in figure 6 showed that about 73.3% of children identified the activity of clapping vs bell followed by 66.7% of them who identified the activity of alarm vs drum beat, 53.3% of them identified talking vs singing and about 46.7% detected whistling vs music. Overall about 60% of subjects performed same or different task.

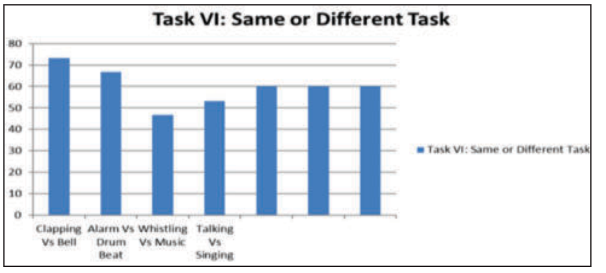

Figure 6 : Achievement (%) of each activity under task VI

Task VII was performed wherein the children had to identify the environmental sounds. From figure 7, it is evident that about 86.7% of the children identified the sounds of crow, cat, dog, vehicle sound and phone ring. 60% of them identified the sound of baby crying and cooker whistle. 73.3% of them identified music and horn, only 33.3% of the children identified the sound of alarm clock.

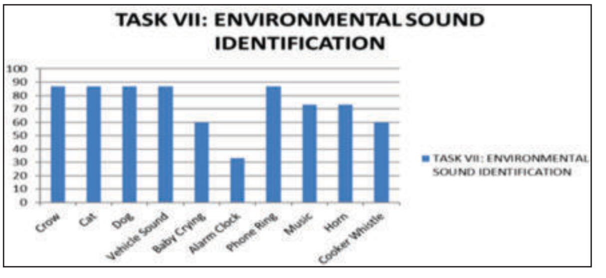

Figure 7 : Achievement (%) of each activity under task VII

Task VIII was about suprasegmentals wherein the children had to identify the difference between the various competing auditory signals. From figure 8, it is evident that about 80% of the children identified the voice of male, female and loud vs soft voice. About 66.7% of the children identified the voice of children and angry vs sad voice and 53.3% of them distinguished the voices between male, female and children. About 13.3% of them distinguished between high and low pitch voice. 40% of the children who participated in the study distinguished between rising and falling voice and only 13.3% children identified the slow and fast voice successfully.

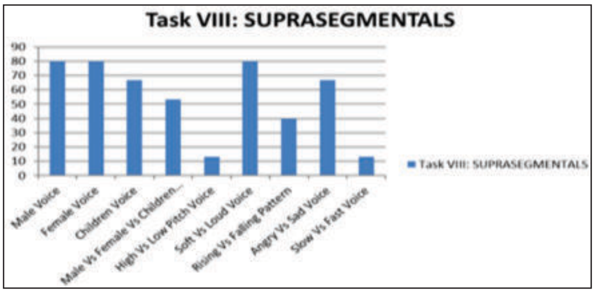

Figure 8 : Achievement (%) of each activity under task VIII

Task IX was the activity of identification between consonant and vowel as the children had to identify the differences between them and produce the same in isolation. The consonant /p/ was identified by 73.3% of the children and /m/ was identified by 80% of them, /h/ and /n/ was identified by 53.3% of them.

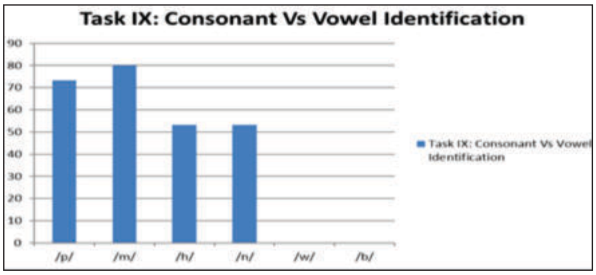

Figure 9 : Achievement (%) of each activity under task IX

Task X was the simple word production wherein the children had to produce simple words of CVC, CVCC and CCVC pattern. From figure 10, it is evident that about 46.7% of the children completed the task of forming words cat, hello and milk and 53.3% of the children formed the words cow, dog and win. 86.7% of the children completed the word give, come and mom and 66.7% of them formed the word go and water and words like ball and apple were formed by 80% and 73.3% of the children respectively. The words hen, van, no and hi could be produces only by less than 30% of the children.

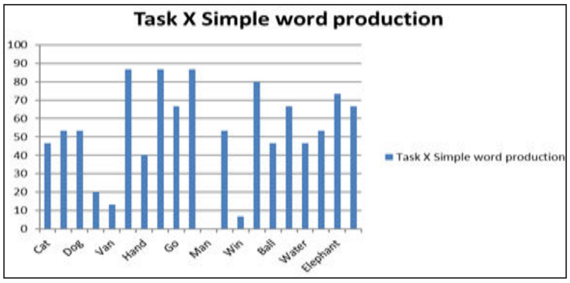

Figure 10 : Achievement (%) of each activity under task X

6.1 Hypothesis Testing

In order to test the hypothesis it is defined that the CAP score should be at least at the median level of CAP score ranging between 0 and 12. For the present study, 6 is the assumed median value because it is the middle value between 0 and 12. The Wilcoxon Signed Rank Test (one sample) was conducted to verify the above hypotheses and to reject the null hypothesis and accept the alternative hypothesis. Therefore, the sum positive ranks were considered as the test value (W+). The test value i.e. the sum of the positive ranks is 3.50 which was found to be significant at a level of 5% as the test value of 3.5 is considered less than the one-tail critical value of 14.00 as evident in table 1.

Variable	CAP Score at the end of 6 months therapy
Sample size	15
Lowest value	2.0000
Highest value	**7.0000**
Arithmetic mean	4.8667
95% CI for the mean	4.1456 to 5.5877
Median	5.0000
95% CI for the median	4.0000 to 6.0000

Signed Rank Test

Table 1: Wilcoxon's Signed rank test CAP Score at the end of 6 months therapy

Test value	6
Number of positive differences	1
Number of negative differences	10
Smaller total of ranks	3.50
Sum of positive ranks(W^+)	3.50
Sum of negative ranks(W^-)	62.5
Two-tailed probability	
One-tail Critical value	14.00

Wilcoxon Signed Rank Test or One sample test was conducted to verify that the children at least achieve median level of CAP score, 6 as assumed. However, the results of the test showed that the evidence of accepting the null hypothesis, H0 is less than 5% and the acceptance of alternative hypothesis wherein the median response was less than 6. One sample t-test was also conducted to test the same hypothesis and the results showed an average CAP score of 4.87 at the end of six months therapy which was tested against the median score of 6 as hypothesised. The t-value (-3.371) was found to be significant at 5% level (-1.761, one tail). Hence, the alternative hypothesis that the median CAP score is less than 6 is accepted.

Table 2: One sample test for verifying Hypothesis

	Mean	N	Std. Deviation	Std. Error Mean
CAP Score at the end of 6 months therapy	4.8667	15	1.30201	.33618
Median score	6.0000	15	.00000	.00000

Wilcoxon test (paired samples)

t-value	Df	Sig.
-3.371	14	.005

Sample 1	Xscr
Sample 2	Yscr

Wilcoxon test (paired samples)

	Sample 1	Sample 2
Sample size	15	15
Lowest value	2.0000	3.0000
Highest value	7.0000	7.0000
Median	5.0000	5.0000
95% CI for the median	4.0000 to 6.0000	4.2649 to 6.0000
Interquartile range	4.0000 to 6.0000	4.2500 to 6.0000

Number of positive differences	4
Number of negative differences	0
Smaller total of ranks	0.00
Two-tailed probability	P = 0.1250

After testing the hypothesis based on Wilcoxon's Signed Test for CAP score after six months of therapy, it was found that the same inferences could be drawn for CAP score for one month after therapy. When the CAP score was compared one month post therapy and after 6 months of therapy, an improvement was observed in the CAP score. Paired sample t-test was performed for testing the hypothesis and it was found that there was significant improvement among the children one month post therapy ($t=2.256$, $P<0.05$). The mean score one month post therapy was 5.13 which was greater than the mean score of 4.87 obtained at the end of six months of therapy.

	Mean	N	Std. Deviation	Std. Error Mean
CAP Score after one month post therapy	5.1333	15	1.12546	.29059
CAP Score at the end of 6 months therapy	4.8667	15	1.30201	.33618

6.2 DISCUSSION

The present study assessed the development of speech due to auditory habilitation or training provided to the children who underwent CI surgery for a span of 6 months. Benefits of the aural habilitation therapy was illustrated in the study through CAP score. During this time, the mean scores of the two samples were compared one month post therapy and after six months of therapy. The CAP score was compared at one month therapy and also after six months of therapy defining that there is an improvement in the CAP score among the children. The mean scores of paired sample t-test showed that there has been a significant improvement in listening skills among the prelingual children who underwent CI. Many studies have assessed the effect of therapy among children with CI. Zhou et al (2013) conducted a study wherein the CAP score significantly increased to 4 post six months and to 7 after one year of CI. Ingvalson et al (2013) in their study showed that auditory-verbal therapy could be effective in improving language and speech outcomes in children recipients of CI.

As a part of auditory training, the tasks such as detection of environmental sounds assigned to the children, majority of them identified the sounds with 100% accuracy such as clapping, bell ring and recognised familiar sounds such as the voices of their mothers and fathers. The children included in the study understood and responded well to the speech sounds of familiar speakers like their mothers and fathers. In the present study, the results showed that the speech intelligibility and auditory performance of trained children improved with training. After one month of auditory habilitation training, the CAP scores increased with improvement in listening skills of the children and subsequently the speech performance.

7. Contribution and Limitations

With the variety of tasks which have been highlighted in the present study, it has contributed to the understanding of auditory training for the CI children in improving their speech perception and listening skills. The novelty of the study is the measures of improvement due to training which has been well documented in the form of CAP score estimated one month post therapy and during six months that helped in understanding the improvement that has taken place among the study participants in terms of speech recognition and listening skills.

The major limitation of the study is the small sample size of the study participants who are the recipients of CI. Due to the small sample size, the results cannot be generalised to other populations as the study was done in a single centre and the results may vary with respect to other factors such as differences in socio-demographic factors. Further studies are required with large sample sizes to generalise with other populations.

8. Conclusion and Recommendations

The present study assessed the development of speech due to auditory habilitation or training provided to the children who underwent CI surgery for a span of 6 months. From the commencement of auditory habilitation training, CAP score of the study participants was measured at the end of six months of auditory training and one month post auditory training. The mean score post one-month of therapy was found to be higher as compared to the mean score obtained after the end of initial 6 months therapy, suggesting improvement in the language development and speech intelligibility among the children who underwent CI. Based on the study findings, speech intelligibility and auditory performance of children with CI improved with training.

The study findings strongly emphasis on the timely detection of deafness in children during their early years of life and the awareness which needs to be created to introduce them to the world of hearing. Intensive training, counselling and follow-up of the children during the training and post- training is essential for the proper speech development. Auditory habilitation should be an inevitable part of management of children with CI.

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