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Comparison between reading comprehension and phonetic and non-phonetic reading skills in children with normal hearing and children with cochlear implants

Abstract

The primary purpose of this study was to explore the reading comprehension skills and phonetic and non-phonetic reading skills in the English language in both, children with normal hearing and children with cochlear implantation. Research in this area is limited with respect to the Indian context and hence a study dealing with these aspects has the potential to broaden our understanding of benefits of cochlear implantation as it helps with academics. The study involved a total of 74 participants across three grades, 5th, 6th and 7th of which 57 were CWNH and 17 were CWCI. All were assessed based on scores attained on 4 assessment tasks, phonetic reading skills, non-phonetic reading skills, short reading passage comprehension and long reading passage comprehension. On statistical analysis, there was a significant difference between scores obtained on phonetic reading, short reading passage comprehension and long reading passage comprehension between 5th and 6th as well as 6th and 7th graders of CWNH. However, no significant difference was recorded between all three standards (5th, 6th and 7th) on all 4 assessment tasks for CWCI group. When grade level comparisons were made between CWNH and CWCI, there was no statistically significant difference of scores on any of the 4 tasks between the two groups at any grade level except that 6th graders of CWNH group performed better in the short reading passage comprehension task as compared to 6th graders of CWCI.

Keywords: cochlear implant, reading comprehension, phonetic words, non-phonetic words

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Abbreviations: CWNH, children with normal hearing; CWCI, children with cochlear implantation

Introduction

The single best predictor of reading success has been known to be phonological awareness. That is, children need to be aware of the sounds of speech in order to acquire knowledge of sound-letter correspondence and use this knowledge to decode the printed word. If a child is not aware of the sounds contained in a word, the child will have difficulty associating sounds with letters.[1] There is a need to study about the inferential ability in reading of children as it would predict their comprehension abilities. This area has received very little attention in Indian context. In a study done by Dalvi and Varsha N.S,[2] inferential ability of second and third standard students were compared using tasks where participants had to select a target word as answer to a question corresponding to a reading passage. A steady increase in the performance of third standard participants was observed.

Children with Hearing Impairment (CWHI) will naturally face difficulty with development of phonological awareness and in turn, have deficits in reading skills. Since the spoken language and reading development in typically developing children is directly proportional,[3] Children with Cochlear Implant (CWCI) ought to benefit in their linguistic development post implantation as compared to the non-implanted congenitally deaf population, as cochlear implants are known to provide better and more synchronised access to spoken language skills in implanted children. A review article[4] reported that the majority of children who are DHH (deaf or hard of hearing) develop spoken language successfully post cochlear implantation. Improved speech perception and production skills have been observed in CWCI. The direct relationship between spoken language and reading development in children with typical hearing (TH), suggests that DHH children may benefit from the use of cochlear implants when learning to read. Another investigation conducted at the Western Pennsylvania School for the Deaf (WPSD)[5].CWCI were compared with their matched peers on scores of two tests, Stanford Achievement Test, 9th Edition (SAT9), and the Pennsylvania System of School Assessment (PSSA) over the course of 4 years, from 2002 to 2006. No significant difference between the implant group and the matched comparison group was seen on any of the scores. Observed trends favour the non-implanted group and implanted group equally. There has been ample research to suggest that children with hearing impairment who undergo cochlear implantation at a young age are able to function close to, if not at par with their typically developing peers in varied domains of life, including academics. However, majority of these studies have been conducted in western countries. CWCI in the Indian sub-continent who are admitted into schools where a non-native language like English is used as opposed to the native languages used at home form a niche sample to analyse for language developmental skills. Hence, there is a need to compare the phonetic and non-phonetic reading abilities and reading comprehension in English between CWCI children with normal hearing (CWNH).The aim of this study was to understand the benefits of early cochlear implantation with reference to the reading comprehension and reading skills of children. The objectives to achieve this aim were to compare the reading comprehension skills, phonetic reading skills and non-phonetic reading skills of CWNH across standards[5-7] as well as CWCI across standards.[5–8] Another objective of this study was to compare

the reading comprehension, phonetic and non-phonetic reading skills standard wise between CWNH and CWCI.

Methodology

Participants

The study included two groups of participants - Children with Normal Hearing (CWNH) and Children with Cochlear Implant (CWCI). CWNH consisted of 63 children in the age range of 9 to 14 years, studying in 5th, 6th, and 7th standards in public schools under Maharashtra state board (SSC board). CWCI included 17 children with implants in either ear (unilateral implant) ranging from 11 to 15 years in age, studying in standards 5th, 6th or 7th in English/ semi-English regular schools in various parts of India. The average scholastic performance of each participant was ascertained through interview with parents and/ or teachers and via school records. Concomitant impairments like Learning disability, ADHD (Attention Deficit Hyperactivity Disorder), ASD (Autism Spectrum Disorder) and ID (Intellectual Disability) component and others were ruled out during these interviews. The details of CWNH are shown in Table 1 and those of CWCI are shown in Table 2.

Table 1 Details of CWNH

Standard	Age Range (y;m)	Mean Age (y;m)	Male		Female	
			NO.	Mean Age	NO.	Mean Age
5TH	10;5-11;1	10;9	8	10;10	8	10;9
6TH	11;0-12;6	11;10	11	11;10	8	11;9
7TH	12;6-14;9	12;5	13	13;3	9	12;9

Table 2 Details of CWCI

Standard	Age range (y;m)	Mean age (y;m)	Male			Female		
			NO.	CA mean (y;m)	Hearing Age mean (y;m)	NO.	CA mean (y;m)	Hearing Age mean (y;m)
5TH	11;0-11;4	11;3	2	11;6	8; 6	2	11; 0	8; 6
6TH	11;0-13;11	12;2	2	12; 0	10; 0	4	12;3	9; 0
7TH	13;0-15;11	14;3	4	14;6	10; 6	3	14; 0	10;8

Materials

Three tools were developed, each for standard 5, 6 and 7. The tools were based on passages and words extracted from scholastic textbooks of typically developing peers. Each material began with a short reading passage for assessment of reading comprehension skills with 6 sentences for standard 5 and 7 and 7 sentences for standard 6. The passage was followed by 3 questions of which 2 were close ended and 1 was open ended in nature. Following this was a long reading passage of 20, 12 and 11 sentences, for 5th, 6th and 7th standard respectively. Simple sentences with an average length of 3-4 words for grade 5th while for 6th and 7th grade, longer sentences of compound and complex nature were also used. Long passage comprehension required recipients to answer 5 questions, 3 of which were multiple choice questions and 2 were open ended. The next task was assessment of phonetic reading skills and the last task was for assessing non-phonetic reading skills. A word list of 10 words for phonetic and 10 for non-phonetic task was built, separately for each class, in accordance with words used significantly in those classes.

The material was validated based on performances of the typically developing children of each category mentioned (5th, 6th and 7th standard). A rehabilitation audiologist and a speech language pathologist also took part in the validation of the material.

The final material consisted of 4 tasks in total, 2 passages (one short and one long) for reading comprehension assessment and 2 word lists (one phonetic and one non-phonetic) for reading assessment.

Procedure

Assessment began by taking the consent of the guardian via a consent form which mentioned the aim of the study, tasks required to be performed by child, assurance of confidentiality, providing task details and approximate duration of assessment. Following consent, a thorough case history was obtained from each participant of both groups which involved collection of all the relevant data and information required from the caregiver, including, general details, medical history, schooling details of the child, and ruling out any learning or concomitant disability. Additional information about hearing loss and pre implant and post implant details were obtained for CWCI participants.

On fulfilling the inclusion criteria for testing, an online schedule was fixed wherein the child attended a video call session with the clinician under the supervision of a guardian. The guardian was provided with the assessment material beforehand and was instructed to keep the child seated in a quiet room with minimal distractions for the entire duration of the test. The caregiver was asked to send the child's responses of the test via messaging platform (WhatsApp). The child was seated comfortably in front of the camera with a pen and paper. The entire testing was done in a single seating.

The test began with the short passage reading comprehension task followed by the long passage reading comprehension task and child was instructed to solve the same. The responses for both these tasks were timed separately and lasted from when the participant started reading the passage until they finished solving the last question. Following this, the clinician proceeded to the reading skills task. Guardian was asked to provide audio recordings of the child as they read each of the word in the word list out loud to their best capacity. These recordings were made separately for both word lists and sent to the clinician for analysis. Caregivers were instructed strictly not to help the child in any way. Only minimal reinforcement on completion of a task was permitted. Clinician avoided taking too many samples of the same test as it may adapt the child and lead to unresponsiveness or fabrication of intended data. On completion of the word list, the testing schedule was concluded.

Scoring

Once all 4 tasks were completed and all data was received, scoring was carried out. For both, the short and long passage, a score of 1

was given for each correct answer and 0 was given for each incorrect answer. In case of open ended questions, a score of ½ was given if some points of the expected answer were present in the recipient's response. Similarly, for both the word lists, a score of 1 was assigned for each word produced correctly and 0 was given for words which had even one misarticulation/ error in their production.

Results

The results were analysed for each of the 4 sections of assessment tasks, namely, short passage comprehension, long passage comprehension, phonetic reading skills and non-phonetic reading skills.

Children with Normal Hearing (CWNH)

For the typically developing group statistical analysis began with analysing each of the 4 categories for normal distribution. The Shapiro-Wilk test of normality revealed that for phonetic reading skills and short passage reading comprehension scores, all three standards, i.e. standard 5, 6 and 7 did not demonstrate normal distribution. While the normality test revealed normal distribution for non-phonetic reading scores for 5th, 6th and 7th grade, for long passage reading comprehension, scores were normally distributed for 6th standard whereas normal distribution was absent for 5th and 7th standard (Table 3).

Table 3 Shapiro- Wilk test results for CWNH

Standard	Phonetic words		Non-phonetic words		Short passage		Long passage	
	w value	p value	w value	p value	w value	p value	w value	p value
5TH	0.789	0.002	0.89	0.056	0.501	0	0.003	0.006
6TH	0.878	0.02	0.931	0.177	0.864	0.012	0.093	0.915
7TH	0.891	0.02	0.969	0.682	0.656	0	0.845	0.824

Following this, Kruskal Wallis test (non- parametric test) was applied to compare the three standards for scores of all 4 tasks. The Kruskal-Wallis H test indicated that there is a significant difference in the scores between standard 5th, 6th and 7th for phonetic scores, short reading comprehension passage, long reading comprehension passage whereas no significant difference was found for non-phonetic scores (Table 4).

Table 4 Kruskal- Wallis test results for CWNH

Task	p value
Phonetic scores	0
Non-phonetic scores	0.019
Short reading passage scores	0.016
Long reading passage scores	0.275

On Post Hoc analysis using the Mann Whitney U test for the 3 tasks depicting a significant difference in the Kruskal Wallis test (phonetic scores, short reading passage scores, long reading passage scores) there was a significant difference between the scores of standard 5 and 6, standard 6 and 7 but not between standard 5 and 7 on all 3 tasks (Table 5).

Table 5 Mann- Whitney U Test results for CWNH

Task	5th and 6th	6th and 7th	5th and 7th
Phonetic scores	0	0.016	0.134
Short reading passage scores	0.011	0.03	0.433
Long reading passage scores	0	0.027	0.816

Children with Cochlear Implant (CWCI)

For children with cochlear implantation the process was similar. Statistical analysis began with analysing each of the 4 categories for normal distribution. The Shapiro-Wilk test of normality revealed normal distribution across all standards for phonetic reading scores as well as for long reading passage comprehension scores. While Non-phonetic reading scores did not demonstrate normal distribution for standard 7 whereas normal distribution for standard 5 and 6, short reading passage comprehension scores were normally distributed only for 6th grade and not for 5th and 7th grade (Table 6).

Table 6 Shapiro- Wilk test results for CWCI

Standard	Phonetic words		Non-phonetic words		Short passage		Long passage	
	w value	p value	w value	p value	w value	p value	w value	p value
5TH	0.945	0.904	0.764	0.096	0.629	0.017	0.972	0.995
6TH	0.988	0.999	0.965	0.965	0.922	0.613	0.908	0.495
7TH	0.814	0.067	0.749	0.02	0.774	0.031	0.854	0.149

The Kruskal Wallis H test indicated that there is a non-significant difference in the dependent variable between standards 5th, 6th and 7th for all 4 tasks of assessment, namely, phonetic reading scores, non-phonetic reading scores, short reading comprehension passage scores, long reading comprehension passage scores (Table 7).

Table 7 Kruskal- Wallis Test results for CWCI

Task	p value
Phonetic scores	0.414
Non-phonetic scores	0.594
Short reading passage scores	0.204
Long reading passage scores	0.697

Since no significant difference was seen within the groups on Kruskal Wallis H test, Post Hoc analysis was not required for the CI sample analysis.

CWNH vs. CWCI

Final comparison was made between CWCI and CWNH grade wise for each of the 4 tasks using the Mann Whitney U Test.

On analytical comparisons, no statistically significant differences were seen between 5th, 6th and 7th standard peers of CWNH and CWCI for phonetic reading skill scores, non-phonetic reading skill scores and long reading passage comprehension scores. With reference to short reading passage comprehension scores, while there continued to be no statistical significance between 5th graders as well as 6th graders of the two groups, there was a significant difference between scores obtained by 7th standard participants of CWNH and those of CWCI (Table 8).

Table 8 Mann Whitney U Test results for CWNH vs. CWCI

TASK	5th standard	6th standard	7th standard
Phonetic scores	0.624	0.44	0.156
Non-phonetic scores	0.294	0.235	0.663
Short reading passage scores	0.839	0.28	0.037
Long reading passage scores	0.576	0.051	0.477

Discussion

The findings of this paper combined with those of previous studies give out some interesting topics of discussion. When comparing the various groups in the 4 domains of assessment it can be easily decoded that children who undergo cochlear implantation at a young age and have a significant hearing age perform almost at par, if not at the same level, of their typically developing peers.

A growing body of literature has shown that sensory restoration can benefit the acquisition of several speech skills such as suprasegmental features, vowels, consonants, as well as intelligibility and conversational abilities[6]. In a recent large-scale study on the reading skills of deaf Dutch children, it was reported that the average reading comprehension scores of deaf children and adolescents were ''shockingly low''. The average reading comprehension for children in the ages of 7–20 years was at a level of first grade of primary education[7]. Geers[8] reported in her study that normal speech and language development is possible for many children who experience only a short period of auditory deprivation during the critical language learning years. It is likely that an even greater proportion of children who receive auditory stimulation before a language delay has been established (i.e., prior to age 2 years), will exhibit normal spoken language when they reach elementary school age. The findings of this study are similar to those mentioned in others. CWCI performed at par with CWNH on almost all areas of assessment, namely, reading comprehension and reading skills which suggests that cochlear implantation helps to establish near normal reading abilities.

While conducting interviews with caregivers, almost all pointed out the critical factor of the COVID-19 impact on their learning. With a shift in the mode of education to online mediums, all parents expressed serious concerns of deteriorating skills due to limited exposure to schooling in the online mode for the 2 years of lockdown. Subjects targeted by parents mainly included language (English) and mathematical skills of their ward. These concerns lead us to believe that there is a possibility of higher scores in CWCI groups on the assessment tasks had it not been for the lockdown.

Qualitative differences were found between the two groups (CWNH and CWCI) especially with reference to the reading skills task. Resonance was affected for most of the CWCI participants as they demonstrated a relatively nasal voice, similar to cul-de-sac nasality. Errors in production of words were phonological for CWCI group and they showed higher prevalence of SODA errors (Substitutions, Omissions, Distortions, and Additions) as opposed to the mispronunciation errors in CWNH.

Conclusion

For children with normal hearing, it can be concluded that non-phonetic reading skills are equally good across all grades (5th, 6th and 7th). With reference to phonetic reading, short passage and long passage reading comprehension skills, it was seen that standard 5 as well as standard 7 students performed better than students of standard 6. It was observed that for all 3 assessment tasks the performance of 5th graders and 7th graders was relatively same.

For children with cochlear implantation, the performance level of children across all 3 grades 5th, 6th and 7th was relatively on the same level for all 4 assessment tasks, i.e. phonetic reading skills, non-phonetic reading skills, short reading comprehension passage and long reading comprehension passage.

On comparing the participants of the two groups (CWNH and CWCI) standard wise for all 4 assessment tasks it can be written that the performance of 5th graders of CWNH and CWCI as well as 7th graders of the two groups for all 4 tasks (phonetic reading, non-phonetic reading, short reading comprehension, long reading comprehension) was comparable. For 6th standard participants, both CWNH and CWCI performed equally well in the phonetic reading, non-phonetic reading and long passage reading comprehension tasks. However, it was observed that 6th graders of CWNH group had significantly better scores in the short reading comprehension tasks as compared to those in the CWCI group.

Reading was chosen because for young children reading skills play an important role and form the basis of advanced learning as they grow. CWNH are enrolled into schools according to their chronological age but that is not the case for CWCI. Hence, this study assessed if CWCI can adapt to the complexity of skills needed as their grade increases. This study shows that comparable performances were seen for all major tasks between CWNH and CWCI indicating that CWCI can perform at higher levels of complexity.

The major limitation of this study is the sample size of the CWCI group and the inequality between CWNH and CWCI group. Another drawback of this study is its period of occurrence. This study was conducted during the COVID- 19 pandemic and in the midst of a lockdown. As a result of this, online mode of communication was used to interact with the participants and close monitoring was maintained throughout the course of each session conducted. Additional behavioural observations which could have been possible in person were not plausible in the online mode. Lastly, this study was conducted only for 3 levels of schooling, i.e. standard 5th, 6th, and 7th. Conducting such a study across all secondary grades would have provided a more holistic idea on the academic development of both CWNH and CWCI. Since the groups were assessed separately, there is a possibility of performance bias which might have affected the results of the study.

Further research can analyse the specific errors seen in production of phonetic and non-phonetic words and whether there is any specific pattern of errors observed for both CWNH and CWCI group participants. Moreover, assessment of resonance characteristics for the CWCI group to check for any significant similarity in their quality (grade-wise or overall) which can be addressed for management.

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Conflicts of Interests

Authors declare no conflict of interests.

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