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Comparison of Reading Development in Children with Hearing Impairment Using Hearing Aids and Cochlear Implant

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Abstract

This study aimed to compare the reading development of hearing aid and cochlear implant users, trained through a phonological awareness intervention program. The design of the study was experimental. The participants of the study comprised 40 randomly selected hearing impaired children with a profound degree of hearing loss using hearing aids and cochlear implants and studying in special education centers of Lahore, Pakistan. The chronological age of the sample extended from 5-7 years, having a hearing age and therapy experience of three years. These children were selected through the use of phonological awareness skill assessment screening tool (PASA). The selected group of students was further divided into control and experimental groups and assessed by reading assessment tool as pre-test. The children of the experimental group were treated through computer-based phonological awareness instructions. Reading assessment (RAT) was used after the intervention as post-test. It was found out that the reading abilities of the treated group of hearing-impaired children significantly improved as compared to the control group. No significant difference in reading abilities and hearing aid and cochlear implant users was noticed, therefore signifying an equal benefit of the program for both groups of children using different amplification systems i.e. hearing aid and cochlear implants.

***Keywords**:* Phonological awareness, amplification, reading abilities, children with hearing impairment

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Introduction

One of the important and crucial milestones to be achieved during the early school years is the development of reading skills. Good reading skill leads to better writing experience, the fundamentals of literacy. Besides, there also exist students who find it difficult to develop reading skills (Genlott & Gronlund, 2013), thus directly affecting their academics and language development (Horowitz-Kraus, Schmitz, Hutton, & Schumacher, 2017; Rabiner, Godwin, & Dodge, 2016).

Various researchers have identified phonological awareness as a foundation of reading proficiency which facilitates the processes involved in word recognition and reading comprehension (Lepola, Lynch, Kiuru, Laakkonen & Niemi, 2016; Silva, 2016). Whereas, Männel, Schaadt, Illner, van der Meer, and Friederici (2017); and Cárnio, Vosgrau, and Soares(2017)has identified poor reading skills as a correlate of poor phonological skills. Like researches with the passage of time and again established a link of poor phonological awareness skills with reading deficiencies in the early school years (Männel, et.al., 2017; Pressley, 2006).

Early reading skills depend on the knowledge of alphabets and the successful phonological process in hearing children (Männel, et.al, 2017; Miller, Leaderberg, & Easterbrook, 2013). The core function of the phonological processing is the storing of new auditory experiences in a manner so they may serve as an anchor on the seashores of the language world. The phonetics of the word sound structure temporarily serves later in the development of the lexical representation, which in time extends and establishes vocabulary (Santos, Bueno &Gathercol, 2006). Likewise, the phonological processing skills predict the literacy ability of deaf children with cochlear implants and is reflected in the early school years (Gear &Hayes, 2011). As phonological awareness skills in hearing-impaired children develops during early childhood thus any deficiency in the phonological awareness skills among the hearing impaired children can be easily witnessed in the pre and elementary school years (Ambrose, Fey, & Eisenberg, 2012; Webb & Ladeberg, 2014).

The reading skill development relies on factors like phonological skill, print/ orthographic knowledge, vocabulary size, fluency and syntactic skill/knowledge (Huang, Tortorelli, &Invernizzi, 2014; Paige, Rupley, Smith, Olinger, & Leslie, 2018). Deficit in one or more of these factors results in a deficit in the reading abilities of children with hearing impairment. According to Suggate (2016), the training in phonological awareness has yielded positive results as it significantly adds to the reading achievement of children at the beginning levels.

Senechal and Fevre (2002) suggested that children with strong oral language skills had rich knowledge of parts of words and their related segments facilitating the growth in phonological awareness, while the young children with deficient oral language competencies, faces problems in the phonological awareness area and related tasks. These children demonstrate challenges in reading achievements at a later stage on the school-age level (Hayiou-Thomas, Carroll, Leavett, Hulme, & Snowling, 2016).

With the advent of computer-based instructional techniques, the pace of learning has become manifold. Computer-based instructional tools have marginalized error occurrence and are being credited as a learning assistant (Silva, 2016; Beddington, Cooper, Field, Goswami, Huppert, Jenkins, 2008; Hasselbring&Goin, 2004). Cárnio, Vosgrau, and Soares(2017) have identified computer-assisted PA instructions as time-efficient when compared to traditional instructions systems. In line with this several computers based phonological programs have been coined and have been declared to yield better results (Nakeva von Mentzer, Lyxell, Sahlén, Wass, Lindgren, Ors, Uhlén, 2013; Silva, 2016). The findings of these studies suggest the effectiveness of computer-based phonological awareness (CB-PA) instructions in terms of phonological awareness and reading skills. These studies provided significant results for different age levels of students from K-1 to school-age children. Such programs enable students to independently perform their tasks with or without the supervision of teachers, which may enhance their reading abilities or eliminate their phonological errors. These programs may facilitate the learners to get maximum advantage from their limited resources. Thus a computer-assisted phonological awareness (CA-PA) intervention program is required to investigate the effect CA-PA instructions on reading development of children with hearing impairment. Likewise, the availability of hi-tech amplification devices, i.e. digital hearing aids and cochlear implants are in better access to the users than ever before. The researchers aimed to find the respective impacts of different hi-tech devices on the development of phonological awareness and to compare the effects of CA-PA intervention in terms of reading development of children with hearing impairment. Thus the study aims to compare the reading development of hearing aid and cochlear implant users through a developed phonological awareness intervention program.

Objectives

The study was aimed to compare the reading development of hearing aid and cochlear implant users trained through a phonological awareness intervention program.

Methodology

The study was experimental in nature. An intervention program (CA-PA) was developed for amplification users living in Lahore and having phonological problems. The population comprised of hearing-impaired children with profound degree of hearing loss in the age range of 5-7 years, using amplification devices and speech rehabilitation for the last three years.

Using the random sampling technique, 40 severe to profound hearing impaired children (cochlear implant users and hearing aid users) were selected for the study from Lahore based on specific inclusion criteria. The inclusion criterion included a screening through Phonological Awareness Skills Assessment (PASA) to establish a phonological error pattern. The selected 40 children were divided into two experimental and control groups through an even-odd criterion. The resultant groups contained 09 hearing aid and 11 cochlear implant users.

Research Tools

The following research tools were used for the research in hand.

Reading Assessment Test (RAT)

Reading Assessment Test (RAT) was developed to assess the reading abilities of the sample students in both groups through the consultation of respective teachers and speech professionals. Two different tests were developed for Pre-test and post-test, based on five elements of reading, i.e. phonics, phonemic awareness, fluency and comprehension which were identified through literature review, interviews with the teachers of hearing-impaired children, psychologists, speech therapists, and audiologists.

The committee approach was used to determine the validity of the tool. Professionals mentioned above were members of the committee constituted for the validation of the test. The committee membership was determined based on qualifications and experience. Only those personnel were selected as members of the committee who possesses at least masters with a minimum of five years of experience in the relevant field. The relative scores of content validity were worked out through Scale Content Validity Index (SCVI) which was 0.97.

Phonological Awareness Skills Assessment (PASA)

In order to measure the phonological awareness skills a tool (PASA) by Milford School District (2010), UK, was adapted for this study. The tool provides an assessment on three levels of phonological awareness, i.e. level 1 (shallow level), level 2 (intermediate level) and level 3 (deep level). Level 1 measures word awareness, rhyme recognition, rhyme production, and syllable segmentation; level 2 provides the measurement on alliterations ID and initial phonemic identification. Whereas, level 3 measures phonemic awareness. The tool was used to screen phonological skills in the sample to validate intervention.

The judgmental pool of experts was used to determine the validity of the tool. Five experts participated and establish the content validity of PASA by using the content validity- judgmental phase (Yaghmale; 2009). The results of judgment made by experts were indicated through SCVI was 95% (.95).

A formal consent from the parent was sought to include their children in the study. A pre-test for reading assessment (RAT) was given to both groups (control group & treatment group). A computer-based phonological intervention was given to the treatment group for three months, with a frequency of three, half-hour sessions a week. At the end of the treatment program, a post-test was given to both groups to assess any differences in the reading abilities.

Treatment Plan

A list of seven consonants was selected for developing a phonological intervention program. These sounds were selected based on their respective features of place; manner and point of articulation, for example, the seven sounds selected have both voiced and unvoiced consonants, oral and nasal consonants, and finally a lateral consonant. Furthermore, the respective frequencies and amplitude of the sounds were also considered while the selection of these sounds, e.g. both high and low-frequency consonants has been used to facilitate the hearing experience of the experimental group. The entire process of consonant selection was done in consultation with the therapists working in the field. These seven consonant sounds /p/, /b/, /f/, /v/, /l/, /m/, and /t/ were selected for intervention program and a list of corresponding 42 words were selected in consultation of the class teachers.

This treatment phase was further divided into six identified sub-skills that include two weeks of rigorous intervention. Worksheets were used to find the efficacy of a given activity. The six identified skills include respective areas in phonological awareness, blending, analysis, etc. The skills include Letter name knowledge, Letter-sound correspondence, spelling real words, blending real words and phoneme analysis.

Data Analysis Procedures

Descriptive statistics and MANCOVA were applied for analysis by using SPSS.

Results

Table 1
Mean, Standard Deviation of control and experiment groups for hearing aids and cochlear implant users (for elements of reading at pre & post-tests)

	Experimental group				Control group			
	Cochlear implant users*		Hearing aid users**		Cochlear implant users*		Hearing aid users**	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Pre-test:								
Phonics	26.27	3.32	25.56	4.48	25.56	3.96	25.00	4.09
Phonemic awareness	11.18	7.52	12.00	9.49	11.27	10.39	9.33	7.29
Reading fluency	5.27	5.18	5.67	5.63	3.73	6.79	1.33	2.18
Vocabulary	1.27	1.01	1.56	1.42	2.18	2.60	1.56	1.13
Comprehension	.09	.30	.11	.33	.18	.40	.00	.00
Post-test:								
Phonics	28.91	1.70	28.67	2.67	28.00	2.41	27.33	2.18
Phonemic awareness	27.45	4.39	27.89	3.44	23.27	4.17	24.56	4.28
Reading fluency	24.36	11.53	18.00	14.58	6.36	9.79	4.44	8.50
Vocabulary	7.82	1.60	7.67	1.41	5.45	1.63	5.67	1.58
Comprehension	3.82	1.40	3.56	1.51	2.18	1.78	2.33	1.80

N=11, N**=9*

Table 1 indicates that the mean of the experimental group, 4 out of 5 elements of reading of post-test of cochlear implant users greater than the means of their pre-test scores, whereas the mean of one element i.e. phonics is not much different on comparison. Similar results were found on the comparison of mean scores for hearing aid users at their pre &

post-test scores. Similarly, on comparison of mean of pre & post-test of the control group of cochlear implant users, there were no remarkable differences found, while similar results were found on comparing means of pre & post-test results of the control group for hearing aid users. In order to check the significant difference in mean MANCOVA was employed. The summary of MANCOVA is given in table 2.

Table2
MANCOVA for reading elements of post-test as dependent variables and devices as covariance

Sources of variance	Multivariate			Univariate ANOVA		
Covariates	Wilk's Λ	*F*	*(p)*			
Device	.82	1.18	(.35)			
Dependent variables				*F*	*p*	Partial η2
Phonics				.134	.72	.004
Phonemic awareness				.933	.34	.03
Reading Fluency				1.39	.25	.04
Vocabulary				.061	.81	.002
Comprehension				.007	.93	.00

Table 2 indicates that a two-way between-groups multivariate analysis of variance was performed to investigate differences in control and experimental groups. The effect of the device (hearing aid & cochlear implant) on five elements of reading, phonics, phonemic awareness, reading fluency, vocabulary and comprehension were measured. The results indicated the insignificant impact of device on elements of reading [Wilk's Λ = .82, $F(5, 27) = 1.18$, $p = .35$, $\eta^2 = .18$]. It was found that the participants who are using hearing aids and cochlear implant (device) were not significantly different on five elements of reading (phonics, phonemic awareness, fluency, vocabulary & comprehension). Both device users equally performed on elements of reading [η^2=.004, .03, .04, .002 and .00].

Table 3
MANCOVA for reading elements of post-test as dependent variables and groups as covariance

Sources of variance	Multivariate		Univariate ANOVA		
Covariates	Wilk's Λ	*F* (*p*)			
Groups	.46	6.25 (.001)			
Dependent variables			*F*	*p*	Partial η2
Phonics			.73	.40	.02
Phonemic awareness			10.43	.003	.25
Reading Fluency			24.19	<.001	.44
Vocabulary			11.98	.002	.28
Comprehension			4.64	.04	.13

Table3 indicates that a two-way between-groups multivariate analysis of variance was performed to investigate differences in control and experimental groups. There was significant difference observed in the performance of both groups. In which experimental group exhibited better results after providing treatment [Wilk's Λ = .46, F (5, 27) = 6.25, $p = .001$, η^2 =.54].The significant effect of experimentation was observed on phonemic awareness, [F (1, 39) = 10.43, $p = .003$, η^2 =.25], reading fluency [F (1, 39) = 24.19, $p < .001$, η^2 =.44], and vocabulary [F (1, 39) = 11.98, $p = .002$, η^2 =.28]. The results indicated that there were large effect of treatment based on the η^2 of .25 (large effect size), 25% of the variances of post- test phonemic awareness, .44 (large effect size) (44%) of the variance of reading fluency and .28 (large effect size) (28%) of the variance of vocabulary observed (Fritz, Morris, & Richler, 2012) for 99% C.I.

Table 4
*MANCOVA for reading elements of post-test as dependent variables and group*device as covariance*

Sources of variance	Multivariate		Univariate ANOVA		
Covariates	Wilk's Λ	F (*p*)			
Groups*Device	.88	.75 (.59)			
Dependent variables			*F*	*p*	Partial η2
Phonics			.036	.85	.001
Phonemic awareness			1.35	.25	.042
Reading Fluency			3.61	.07	.10
Vocabulary			.74	.39	.02
Comprehension			.68	.42	.02

Table 4 indicates that a two-way between-groups multivariate analysis of variance was performed to investigate differences in control and experimental groups in comparison to device. Five elements of reading (post-test) being dependent variables were used: phonics, phonemic awareness, reading fluency, vocabulary and comprehension and combination of groups and device were taken independent variables. The overall model for the covariate of group*device was not significant, Wilk's $\Lambda = .828$ $F(5, 27) = .75$, $p = .59$, $\eta^2 = .12$. While the overall model was not significant, the lack of significant bivariate results confirmed the lack of model significance. Participants of group*device on five elements of reading (phonics, phonemic awareness, fluency, vocabulary & comprehension) did not significantly differ. Due to the lack of significant individual effects of device on five elements of reading, phonics, $F(1, 39) = .36$, $p = .85$, phonemic awareness, $F(1, 39) = 1.35$, $p = .25$, fluency, $F(1, 39) = 3.61$, $p = .07$, vocabulary, $F(1, 39) = .74$, $p = .39$, and comprehension, $F(1, 39) = .68$, $p = .42$ for 99% C.I. The interaction effect of program group and device was not significant, Participants of group*device on five elements of reading (phonics, phonemic awareness, fluency, vocabulary & comprehension) did not significantly differ.

Table5
ANCOVA for post-test as dependent variables and pre-test as covariance

Source	Sum of squares	df	Mean Square	*F*	*P*	Partial η2
Pre-test	4194.24	1	4194.24	28.51	<.001	.45
Groups	2902.03	1	2902.03	19.73	<.001	.36
Device	276.84	1	276.84	1.88	.18	.051
Groups *Device	77.85	1	77.85	.53	.47	.015
Error	5148.59	35	147.10			

Table 5 indicates 2 X 2 between-groups analysis of covariance. It was conducted to assess the effectiveness of the intervention program by post-test reading results in terms of amplification device (hearing aid users and cochlear implant users). The independent variables were pre-test reading scores and device and scores on the post-test (reading) were used as the dependent variable. Preliminary checks were conducted to ensure that there was no violation of the assumptions of normality, linearity, homogeneity of variances, homogeneity of regression slopes, and reliable measurement of the covariate. The main effects was statistically significant, program: $F(1, 35) = 19.73$, $p<.001$, with a large effect size (partial eta squared=.36); while device: $F(1, 35) = 1.88$, $p = .18$ had no statistically significant effect. After adjusting for pre-test scores of reading, there was no significant interaction effect, program*device, $F\ (1, 35) = 0.53$, $p=.47$, with a small effect size (partial eta squared = .015). These results suggest that hearing aid users and cochlear implant users exhibited an equal level of reading abilities or the intervention program thus being equally beneficial for hearing aid users and cochlear implant users.

Discussion

The current study was aimed to develop reading abilities in children with hearing impairment using hearing aids and cochlear implant. Learning to read is a major problem of children with H.I (Marschark, Sapere, Carol, Convertino, Mayer, Wauters, & Sarchet, 2009). Fluent reading is a dream – a dream of every child. Children with hearing impairment have issues related to their impaired hearing like academic and literacy skills. Children use amplification devices like hearing aid (H.A) and cochlear implant (CI) to reduce the effect of impairment related issues.

Although, cochlear implant is a well-liked treatment now a days but on the other hand, CI with its several issues such as affordability and literacy limitations involved (Nabeel, Sohail & Tanveer, 2012). A program is desirable to prevail over such issues related to HA and CI users. Mastery in Comprehension skill is complicated for children with hearing impairment. The fifth element of reading is comprehension which is the most complex component of reading. Understanding and language proficiency significantly contribute to develop reading comprehension

Though cochlear implant (CI) users exhibited better reading comprehension skills as compare to hearing aid users [ibid]. But results showed that the CB-PAI is in the same way usefull for both type of device users (Bickham, 2015).

Conclusions

The intervention has been found effective in terms of developing phonological skills in children with hearing impairment in general and has resulted in improved performance in the reading skills of the experimental group. There was a significant difference observed in the performance of both groups, the experimental group exhibited better results after the treatment.

On the other hand, however, when comparing the effects in terms of type of amplification device, i.e. hearing aid and implants, there was no significant difference found, establishing an equal benefit for both types of aids. The results suggest that hearing aid users and cochlear implant users exhibited an equal level of reading abilities or the intervention program thus being equally beneficial. Since, there was no significant effect of device on five elements of reading, (i.e. phonics, phonemic awareness, fluency, vocabulary & comprehension).

Recommendations

The present study was based on the effects of a phonological awareness intervention program on reading the development of children with hearing impairment. On considering the problem of generalization of results of the experiment, the small number of participants who participated in the experiment should be replaced with a large sample size in future studies which may provide greater ability to generalize the findings of an experiment in all relevant contexts (Field, 2009). Replica studies should be conducted by changing variables including bigger sample size, age group, language, and consonants, etc.

The academicians and teachers need to lay more stress on phonological development in general and particularly for hearing impaired students due to the strong relationship of phonological awareness with reading function. Since literacy relates reading, a better foundation in terms of phonological awareness will yield better readers.

RAT has served as a good screening tool for reading skills during this study. It is recommended that the tool be used while the reading assessment of children with challenged hearing. Computer-based instruction has also been a motivating factor for the respective population and needs to be embarked upon in routine classroom activities.

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