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Adequacy of Computer Assisted Phonological Awareness Intervention Program for Deaf Children

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Abstract

The purpose of the study was to compare the efficiency of computer-assisted (CA) phonological instructions on three levels of phonological awareness (PA) i.e. shallow, intermediate and deep on children and PA skill level comparison of hearing aid users and cochlear implant users. The study sample consisted of 40 children with age range 5-7 years, who used amplification devices in the form of a hearing aid and cochlear implant. While the selection criterion included a hearing age of three years. A developed Computer-assisted instructional plan was used to develop PA skills of hearing aid users and cochlear implant. This plan was validated under the supervision of senior experts in the field of speech and language therapy. Individualized sessions were provided to the students and recorded for ready referrals. After a treatment of three months for phonological development, the effect was observed on respective three levels of PA. A significant difference was observed on all three levels signifying the efficacy of intervention through computer-assisted instruction. Irrespective of the type of amplification system, i.e. hearing aid or cochlear implant, the treatment benefitted both groups.

Keywords: Phonological awareness, levels of PA, computer-assisted phonological awareness instructions (CA-PAI), deaf children, cochlear Implant users & hearing aid users.

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Introduction

Phonological awareness (PA) refers to the ability to understand the sounds and structure of sounds in words. PA being an area of oral language provides the understanding of the structure of words in oral language. This ability (PA) is considered as early literacy skill which is associated with success in reading (Hodgson & Holland, 2010). Word awareness, syllable awareness, rhyme awareness, alliteration and sound (phonemic awareness) are the foundation of PA (Desjardin, Embrose & Eisenberg; 2009). These awareness skills refer to the continuum of PA development which is described in three levels, i.e. shallow level (word level, rhyme and syllables), intermediate level or middle level (alliteration identical initials (ID) & initial sound segmentation) and deep level (phonemic awareness (onset & rime)) (Miller, 2010; Schuele & Boudreau, 2008). In children (Philips & Torgesen, 2006; James, Rajput, Brinton, & Goswami, 2007), PA is a strong reading predictor. As vocabulary is an important component learning to read (Desjardin, Embrose & Eisenberg; 2009), so it depends upon the ability of children to comprehend and making of new words (vocabulary/phonological awareness) by using different sounds which is a prediction to enhance reading ability of children (Phillips & Torgesen; 2006) and possibly the same for deaf children with early implant (cochlear implant or hearing aid) (James, Rajput, Brinton, & Goswami., 2007). Hearing impaired children have great risk of reading problems (Marschark, 2007; Hayiou-Thomas, Carroll, Leavett, Hulme, & Snowling, 2016) and oral language skills (Hayiou-Thomas, Carroll, Leavett, Hulme, & Snowling, 2016). All these along with phonological awareness are based upon functional hearing in deaf children. Many researches refer to the good speech perception in deaf children due to their early implants (CIs or hearing aids) (Hype, Punch, & Grimbeek, 2011).

Phonological awareness usually develops in a continuum of skills which provides the tasks according to the range of difficulty which can be described in the form of a shallow level to deep levels (Miller, 2010; Pufpaff, 2009). Shallow level involves tasks relatively low difficult (Schuele & Boudreau, 2008), i.e. word awareness, rhyme recognition, rhyme production, and syllable segmentation. These tasks contribute to develop spellings in spoken words on the bases of understanding of sound structure (Carson, 2012), which provides the awareness of larger sound units (e.g. rhyming & segmentation) in children before they understand the smaller sound units (e.g. phonemes) (Schuele & Boudreau, 2008). Therefore tasks based on syllable awareness and rhyme awareness are

relatively easier as compared to phonemes (Liberman, Liberman, Mattingly & Shankweiler, 1980).

The L2 (Intermediate level/middle level) of PA involves tasks which are relatively difficult as compared to the tasks of level 1. These tasks are based on alliteration ID and initial phoneme identification (Miller, 2010). Third level of PA skills (also called Deep level) provides understanding on deeper phonological units based on more complex level tasks (Schuele & Boudreau, 2008), i.e. phoneme blending and segmenting. There are a number of cognitive operations involved in every level of PA skills. These operations vary in difficulty levels, e.g. blending, identifying and segmenting tasks need only one cognitive operation. Whereas manipulation and deletion tasks which are more difficult required two cognitive operations (Carson, 2012). These three levels of PA skills leads towards the linguistic features such as words and syllable structure, manner of articulation and sounds (listening comprehension) and influenced by the PA tasks (Al Otaiba, Kosanovich, & Torgesen, 2012). Mastery at one level of PA skills does not imply the development at the next level of PA skills due to overlapping of these skills in different areas of PA. Anthony, Lonigan, Driscoll, Phillips and Burgess (2003) investigated that it is not necessary for children to demonstrate mastery at an easier level of PA before showing development at more complex level. Use of a computer as an instructional technique is becoming common nowadays. The recognition of the importance of technological tools is increasing that can provide assistance in children's learning and can provide individualized instruction (Beddington, Cooper, Field, Goswami, Huppert, Jenkins, 2008). Computer-assisted instructions are considered as time efficient and more consistent as compared to traditional PA instructions (Carson, 2012). In order to minimize the use of resources in traditional PA intervention, there are number of computer-assisted (CA) PA training programs which have been developed (Torgesen, & Mathes, 2002). The impact of CA-PA training has bene investigated in several research studies (Lonigan, Driscoll, Phillips, Cantor, Anthony, & Goldstein, 2003). These indicate the effectiveness of such training instructions to develop PA skills of children from different age groups. This CA-PA was specially designed for hearing impaired by considering their age accordance with manners of articulation and threshold of hearing. The design of CA-PA was also useful for normal children to address their phonological problems. The design also addressing the need for developing countries like Pakistan which may have a problem for use of online computer applications due to unavailability of internet connection in some areas of countries. Thus, it is important to examine the adequacy

of a developed and validated CA program for PA to ensure the effectiveness of the program for hearing impaired children in a Pakistani setup and compare the PA skills of deaf children who are using amplification devices.

The phonological awareness intervention program was developed on the bases of listening skills of hearing impairment children who were using hearing aids and cochlear implant. As phonological awareness intervention may be used by speech and language therapists as an effective simultaneous approach for speech disorders (Moriarty, & Gillon, 2006). The experts agree with the use of computer-assisted speech and language therapy as an effective technique to overcome speech problems (Saz, Yin, Lleida, Rose, Vaquero, & Rodríguez, 2009). Thus, this intervention program may use an alternative approach for the Speech and language therapists as well as parents in order to train these children providing auditory training or AVT for other related disorders. The review of the literature indicated the unavailability of documented research work on phonological awareness intervention program in Pakistan based on listening skills development, so this study will shed light to future researchers. This study attempts help the teachers of hearing-impaired children (with hearing aids and cochlear implantation) as well as for normal children to overcome their phonological problems.

Objectives

This study was conducted to compare the effectiveness of computer-assisted (CA) phonological instructions on three levels of phonological awareness (PA) i.e. shallow, intermediate and deep on deaf children with hearing aid users and cochlear implant users and PA skill level comparison of hearing aid users and cochlear implant users.

Methodology

A pre-test-post-test research design was used. Population of the study was comprised of children with severe to profound hearing loss using amplification devices (hearing aid and cochlear implant) of Lahore district having age range between 5-7 years and either using hearing aids or had cochlear implant from last three years in Pakistan.

Participants

Forty (40) hearing impaired children using amplification devices for last three years were selected randomly as a sample through simple random sampling technique. The selection criteria also included hearing aid or cochlear implant users undergoing regular speech and language/ AVT therapy. This sample was further divided into control and experimental group. Every child with even serial number was selected for experimental group, whereas rest were selected for control group. Each group constituted twenty children. Altogether, each group contained 11 cochlear implant and 09 hearing aid users.

Instruments

In order to measure the phonological awareness skills on three levels, Phonological Awareness Skills Assessment (PASA) (Milford School District, 2010) was employed. The assessment tool was primarily developed at Milford School District, UK and adapted by the researcher for this particular 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 the phonemic awareness (blending onset and rime, blending phonemes, medial phoneme identification, final phoneme identification and reading CVC words (consonant-vowel-consonant). In order to show mastery of a particular component, the child has to complete the given task at an acceptable level. For example for mastery in level 1 and level 3, not more than one item can be missed while for mastery in level 2 not more than two items can be missed. This assessment was applied on an individual basis. Items for each segment from three levels of PA were formulated from the list of 42 words developed on seven sounds selected from literature according to the age range 5-7 years of deaf children in consultation with professionals in the field.

The validity of PASA was measured using the judgmental pool from five experts by using *'content validity-judgmental phase*' (Yaghmale; 2009). The results of expert's judgment were indicated SCVI (Scale content validity index) overall was 95% (0.95). Whereas SCVI as relevance 96% (0.96), clarity 96% (0.96), simplicity 93% (0.93) and

ambiguity 93% (0.93) (0.78 or higher for 3 or more experts (Polite, Beck, & Owen, 2007)).

Data Collection

Data were collected by using PASA as pre-test & post-test from control and experimental group. Before the start of intervention, a pre-test was conducted in a speech & language therapy center of Lahore. The pre-test was administered by the researcher with the help of a research assistant on a one to one (individual) basis. PASA, which was based on three level of PA, administered as a pre-test. It provides information on each level of PA particularly. Instructions for PASA administration were given at each level of PA on every component which was strictly followed at the time of pre-test accordingly. All three levels were completed according to the given set of instructions and responses were recorded on a separate set of the test sheet. As PA skills are overlapping in different areas and mastery on one level PA skill does not indicate the development on next level, so it is not necessary to identify specific level of PA but performance on each level matters. This procedure of pre-test was completed in five days. After completion of the pre-test, an intervention was provided to the research group (experimental group) which extended to three months. Afterwards, a post-test was conducted on both control and experimental groups at the end of treatment on similar lines. Data were analyzed using SPSS.

Intervention/Treatment

A validated Computer Assisted Phonological Awareness (CAPA) intervention program was used as a treatment to develop PA on three levels of PA, This lasted three months (12 weeks on alternate days). This program was designed for seven consonant sounds. A list of 42 words was developed from these sounds for elicitation. Based on these words, 227 computer-assisted activities were developed which were divided into six phases; i) Letter name knowledge- phonemic awareness (Image to Image), ii) Letter-sound correspondence- phonemic awareness (Image to sound & Sound to sound initial, middle & final), iii) Spelling real words- phonemic awareness & segmentation, iv) Reading real words- Rhyme & deletion (Sound to word), v) Blending real word, and vi) Phoneme analysis-phonemic awareness & segmentation (Trinh; 2014 & RTI, 2015).

The intervention was provided for 12 weeks on alternate days with the help of a trained research assistant. A number of one-to-one session were

provided to the children of the experimental group. Each session was of half an hour duration. Progress on each phase was assessed by using worksheets at the completion of that phase.

Findings/Results

Table 1

Paired sample test for three levels of phonological awareness

	Pre -test			Post-test			Paired sample t-test		
	M	S.D	S.E	M	S.D	S.E	T	df	P*
Level 1: Hearing aid users (N= 09)	16.3	3.6	1.2	21.5	1.9	0.6	-3.8	8	.005
Cochlear implant users (N=11)	18.6	4.8	1.4	21.6	2.3	0.7	-2.4	10	.035
Level 2: Hearing aid users (N= 09	2.1	1.9	.6	9.6	.7	.24	-9.3	8	<.001
Cochlear implant users(N=11)	3.0	1.8	.5	9.6	.9	.28	-13.3	10	<.001
Level 3: Hearing aid users (N= 09)	5.1	4.9	1.6	23.7	1.6	.53	-13.6	8	<.001
Cochlear implant users (N=11)	6.9	7.1	2.1	24.0	2.4	.71	-8.7	10	<.001
PA Total: Hearing aid users (N= 09)	23.6	8.7	2.9	54.6	3.8	1.3	-12.1	8	<.001
Cochlear implant users (N=11)	26.2	11.4	3.4	54.9	5.5	1.7	-9.1	10	<.001

*p<0.05

Table 1 indicates the mean and standard deviation of pre-test and post-test of hearing aid users and cochlear implant users of experimental group at level 1 (shallow level), level2 (intermediate level), level 3 (deep level) and PA Total and comparison of their means. On comparing means scores of pre-test and post-test, significant difference was found between the means of hearing aid users on three levels of PA, at L1 (t (8) =-3.8, p<.05) with large effect size (Etta square=0.64; 95%CI); at L2 [t (8) =-9.3; p<.05] with 95%CI and large effect size (Etta square=0.90) and at L3 (t (8) =-13.6; p<.05 with 95%CI) and large effect size (Etta square=0.96). With PA total (Hearing aid users), there was a large significant difference in comparing pre & post-test means (t(8)=-12.1; p<.05 with 95%CI) and large effect size (Etta square=0.94), it showed that hearing aid users exhibited better PA skills after providing computer-assisted intervention. Similarly on comparison of mean scores of cochlear implant users significant difference was found on all three levels; (t (10) =-2.4; p<.05 and 95%CI) with large effect size (Etta square=0.25) at L1,[t (10) =-13.3; p<.05 and 95%CI] with large effect size (Etta square=0.94) at L2 and (t (10) = -8.7; p<.05 with 95%CI) and large effect size (Etta square=0.88) at L3. It showed that both hearing aid users and cochlear implant users equally benefitted the computer-assisted program for PA level 1, level2 and level3. While on comparing mean scores of pre-test and post-test cochlear implant users (PA Total) also exhibited better results on PA skills after providing computer-assisted PA intervention, i.e. t(10)=-9.1; p<.05 with 95%CI and large effect size (Etta square=0.88).

Table 2

Descriptive statistics of three PA levels

	Pre-test				Post-test			
	Control group		Experimental group		Control group		Experimental group	
	M	*S.D*	*M*	*S.D*	*M*	*S.D*	*M*	*S.D*
Hearing aid users (N= 9+9): Level 1- Shallow level	15.6	3.3	16.0	2.9	17.8	3.3	22.7	0.5
Level 2- Intermediate level	4.7	4.1	5.1	4.9	10.8	3.2	23.7	1.6
Level 3- Deep level	1.8	1.9	2.1	1.9	4.7	1.3	9.6	0.7
PA Total (N= 9+9)	22.0	8.5	23.2	5.7	33.2	6.9	55.9	1.9
CI users(N=11+11): Level 1- Shallow level	17.0	2.6	16.5	2.4	19.7	2.3	22.3	1.1
Level 2- Intermediate level	9.5	7.2	6.9	7.1	16.5	4.4	24.0	2.4
Level 3- Deep level	3.2	2.1	3.0	1.8	6.7	1.6	9.6	0.9
PA Total (N=11+11)	36.5	7.3	39.7	6.5	42.9	7.4	55.8	4.2

Table 2 showed the mean and standard deviation scores of control and experimental groups of hearing aid users on the basis of their pre-test and post-test scores at L1 (shallow level), L2 (Intermediate level), L3 (Deep level) and Total (overall) of PA skills. It also indicated the control and experimental groups mean and standard deviation scores of cochlear implant users of their pre-test and post-tests. It was found that mean scores of the control group and experimental group at the pre-test results of hearing aid users and cochlear implant users were not so different but they found different at their post-test scores. In order to measure the significant difference, the mean scores of control and experimental group were compared by using independent sample t-test.

Table 3

Independent sample t-test (control & experimental group) on three PA levels

	Pre-test			Post-test		
	t	df	p	t	Df	P*
Hearing aid users Level 1- Shallow level	-0.3	16	.8	-4.4	16	<.001
Level 2- Intermediate level	-0.2	16	.8	-10.8	16	<.001
Level 3- Deep level	-.4	16	.7	-9.7	16	<.001
PA Total	-0.4	16	.7	-9.4	16	<.001
CI users: Level 1- Shallow level	0.5	20	.6	-3.3	20	.003
Level 2- Intermediate level	0.8	20	.4	-5.0	20	<.001
Level 3- Deep level	.2	20	.8	-5.0	20	<.001
PA Total	-2.7	20	.2	-5.1	20	<.001

*p<0.05

Table 3 indicated the comparison of means (control and experimental groups) of device users (hearing aid users & cochlear implant users) before treatment (pre-test) and after treatment (post-test) by using independent sample t-test at the shallow level (L1), Intermediate level (L2), Deep level (L3) and Total (overall) of PA skills. This comparison showed that no significant difference was found before treatment of hearing aid users between control and experimental groups on all levels of PA but significant difference was found on all three PA levels after treatment (t (16)=-4.4; p<.05 with 95%CI) and large effect size (Etta square=0.56) at L1, (t(16)= -10.9; p<.05 with 95%CI) and large effect size (Etta square=0.88) at L2 and at L3 [t(16)= -9.7; p<.05 with 95%CI] and large effect size (Etta square=0.85). On comparison of means for overall PA skills (hearing aid users) before and after providing computer-assisted treatment, significant improvement in PA skills was found [t (16) = -9.4; p<.05 with 95% CI and large effect size (Etta square=0.85)]. Similar results were found for cochlear

implant users after treatment (t (20) =-3.3; p<.05 with 95%CI and large effect size (Etta square=0.37) for L1), [t(20)=-5.04; p<.05 with 95% CI and large effect size (Etta square=0.56) for L2], [t(20)=-5.0; p<.05 with 95% CI and large effect size (Etta square=0.55) for L3] and [t(20)=-5.05; p<.05 with 95% CI and large effect size (Etta square=0.56) for PA Total]. These similar results indicated that hearing aid users and cochlear implant users have a significant improvement on level 1 (Shallow level), level 2 (Intermediate level), level 3 (Deep level) and PA Total (overall) of PA skills after use of computer-assisted intervention program on PA.

Table 4

Descriptive statistics of PA Skills Assessment of Hearing Aid Users and CI Users

	Pre-test				Post-test			
	Control group		Experimental group		Control group		Experimental group	
	M	S.D	M	S.D	M	S.D	M	S.D
Level 1: Hearing-aid users	15.6	3.2	13.0	1.4	17.78	3.3	22.7	.5
Cochlear implant users	17.0	2.7	16.5	2.4	19.73	2.3	22.3	1.1
Level 2: Hearing aid users	1.8	1.9	1.6	1.3	4.67	1.3	9.6	.7
Cochlear implant	3.2	2.1	4.1	1.3	6.73	1.6	9.6	.9
Level 3: Hearing aid users	4.7	4.1	4.2	3.5	10.78	3.2	23.7	1.6
Cochlear implant	9.5	7.2	8.7	5.1	16.45	4.4	24.0	2.4
Total: Hearing aid users	22.0	8.5	18.8	4.8	33.22	6.9	55.9	1.9
Cochlear implant	36.5	7.3	29.7	7.6	42.91	7.4	55.8	4.2

*Hearing aid users; N= 09; **Cochlear implant users; N=11

Table 4 indicates the mean and standard deviation scores of hearing aid users and cochlear implant users on three levels of PA and total overall scores of PA skills at pre-test and post-test (control & experimental groups) results. These scores indicated the difference in mean scores of hearing aid users and cochlear implant users at pre-test of the experimental group. At L1 the mean scores at pre-test of hearing aid users and cochlear implant users are almost same, similarly, these scores are same at post-test results of the experimental group (hearing aid users & cochlear implant users) at L2, L3 and total. But mean scores of the pre-test results of hearing aid users and cochlear implant users in the experimental group are different at L2, L3 and total. To check the significant difference in mean scores of hearing aid users and cochlear implant users at pre-test results and post-test results, independent sample t-test was employed in table 5.

Table 5

Comparison of PA Skills of Hearing Aid Users and Cochlear Implant Users

	Pre-test			Post-test		
	t	df	p	t	Df	P*
Control group: Level 1	-1.1	18	.3	-1.6	18	.1
Level 2	-1.5	18	.2	-3.07	18	.007
Level 3	-1.8	18	.1	-3.5	18	.004
Total	-4.1	18	.001	-4.1	18	.001
Experimental group: Level 1	-3.8	18	.001*	.9	18	.3
Level 2	-4.3	18	.000*	.03	18	.9
Level 3	-2.2	18	.038*	-.4	18	.7
Total	-3.8	18	.001*	.05	18	.9

*P<0.05

Table 5 indicates the comparison of means between hearing aid users and cochlear implant users in control and experimental groups at L1, L2, L3 and total PA skills. The insignificant difference was observed at post results at L1, L2, L3 and Total PA skills of the experimental group. It indicates that there is no effect of device on PA skills of hearing aid users and cochlear implant users or both hearing aid users and cochlear implant users exhibited the same PA skill at all level and also at total (overall) with almost no effect (Etta squared values 0.05, 0.00, 0.007 and 0.0001 at L1, L2, L3 & total PA skills resp.). Thus, the intervention of PA was equally beneficial for both device users (hearing aid users & cochlear implant users). Although, it was observed PA skills of hearing aid users and cochlear implant users (experimental group) before intervention were significantly different, i.e. at L1, t (18) = -3.82, p=0.001; at L2 t (18) = -4.29, *p*= 0.000; at L3= -2.24, p=0.038 and PA total, t (18) = -3.76, p=0.001.

Discussion

The current study was conducted to compare the effects of CA-PAI for PA skills development of different amplification user deaf children on all three levels, i.e. shallow, intermediate and deep levels of PA as well as

overall PA skills. PA skills significantly contribute to develop language and reading skills of children (Cárnio, Vosgrau, & Soares, 2017). The results indicated that the PA skills of hearing aid users and cochlear implant users were significantly different before intervention which might be due to the late use of device (hearing aid or cochlear implant) or hearing age, use of speech and language therapy (Ching & Cupples, 2015) and SES of parents (McDowell, Lonigan, & Goldstein, 2007). But findings of post-test were indicated the usefulness of CA-PAI to develop phonological awareness for both device users in terms of no significant difference in PA skills of both device. Although the PA skills of hearing aid and cochlear implant users were significantly different with traditional approaches (Ching, & Cupples, 2015; Johnson, & Goswami, 2010). Furthermore both device users equally benefited on all three levels of PA via CA-PAI. Before intervention the significant difference was found on all three levels of PA. Shallow level (L1) being a simple level, cochlear implant users performed better as compare to hearing aid users. Similar findings were found on intermediate (L2) and deep (L3) levels, it might be due to overlapping of related skills in three levels.

Conclusion

Computer-assisted phonological awareness instructions have a significant effect on phonological awareness skills of hearing aid users and cochlear implant users. The computer-assisted instructions are beneficial to develop phonological awareness skills of hearing-impaired children (hearing aid users & cochlear implant users). These instructions are useful to develop phonological awareness skills at the shallow level, intermediate level as well as the deep level of hearing-impaired children (hearing aid users & cochlear implant users). On comparison of PA skills of hearing aid users and cochlear implant users found equal after PA intervention, although there was significant difference found in PA skills of both groups before intervention. Thus, these children were equally beneficiated at all levels (shallow, intermediate & deep) of phonological awareness skills with the use of computer-assisted PA instructions which predicts oral language development and early reading skills of hearing-impaired children.

Recommendations

The present study was aimed to compare the efficacy of computer-assisted phonological awareness intervention program for development of phonological awareness skills of HIC at shallow, intermediate and deep level. Generalisation of experiment results due to a small number of the experimental group is considered to be a problem, it should be done with a large group of a sample for future researchers which provide a greater chance for generalization of the results of the experiment in all related contexts (Field, 2009). The present study was conducted in Lahore, being a provincial capital, is enriched with all necessary services and facilities and provides more pace to researchers, thus it should be done in other cities of Pakistan as well for a different environment and cultural aspects. There are number of variables which need to investigate in Pakistani setup for CA-PA intervention used in class room settings. These may be teacher's professional qualification and knowledge of PA, basic computer literacy skills, availability of technology and demographic features (e.g. socio-economic status, parental qualifications and gender etc.). These variables require in-depth investigation in future studies with large sample size and in different educational setups by using computer-assisted instructions for PA. Furthermore, the present study was conducted for hearing impaired children but the efficacy of CA-PA program should be investigated for normal children in future. Although computer became a need of the day but access to computer for everyone is still a question in Pakistan. Along with this support from parents and teachers for use is computer is another important element and these two important elements cannot be change by researcher. Thus it is important to explore alternative ways which can overcome such problems. Furthermore it is essential to provide training to teachers to support such kind of computer assisted educational programs. For this refresher courses or in-service training programs may be helpful. The CA-PA program was an offline program which can be converted into an android application and helpful for teachers as well as parents after little practice to teach those children who have phonological problems or reading difficulties.

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