Pre-Arithmetic School Readiness Test for Children with Hearing Impairment

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ABSTRACT

The study was undertaken with the aim to develop a test for assessing the readiness of children with hearing impairment (CWHI) in pre-arithmetic skills and checks its utility by administering the test on typically developing children as well as preschool children with hearing impairment. The study was carried out in two stages where the first involved the development of the test and the second dealt with field testing it on typically developing children and CWHI. The test items targeted to elicit responses through the visual and auditory modality for open and closed type of questions. The scores obtained by the participants were analysed to find out if there is any significant difference between the two participant groups and also within each group for the categories and subcategories of questions in the tool. CWHI performed poorly when compared to the typically developing children in all the sub categories except for scores in the visual modality for closed type of questions. Significant main effect was observed for all the major categories and among the sub categories no significant difference was observed for the visual tasks for the typically developing children and for the auditory task for the CWHI. The newly developed test was found to be sensitive to the difficulties of CWHI in learning pre-arithmetical concepts.

INTRODUCTION

It has been well documented that hearing impairment in early childhood has an adverse affect on speech and language development. Impairment in the development of speech, language and oral communication skills in turn is known to hinder the educational development of children. Paul and Jackson (1993) reported that differences in language abilities consequent to deafness affects a student's ability to perform in traditional academic areas. The delay in educational achievement of children with hearing impairment compared to their hearing peers has been noted to occur since the educational system is highly language based. Paul and Quigley (1990) reported that students with deafness or partial hearing impairment have considerable difficulty succeeding in an educational system that depends primarily on spoken word and written language to transmit knowledge. It has also been reported earlier by Greenber and Kushe (1989) and Martin (1985) that children with mild-to-moderate hearing loss achieve below expectations, based on their performance on a test of cognitive ability. Goldin, Meadow and Mayberry (2001) observed that acquisition of first language and ongoing language development, throughout early childhood and elementary school, were found to be necessary for individuals to become skilled readers.

The above research brings to light that generally children with hearing impairment are found to be performing below their age-appropriate grade levels. In order to help them enhance their performance, it is necessary that they undergo special intensive academic training.

Importance of Pre School Education

Pre-school education has been considered very important for children, as it is the first step towards entering the world of knowledge as well as a healthy and purposeful life. Ramachandran et al. (2003) reported that pre-school education helps children become more independent and confident as well as promote all round development of the children and a place for them to gain the basic lessons of life. The learning and playing activities in pre-school was found to help children to become more confident and independent. Likewise, Kaul (2002) suggested that pre-primary education was very important for the development of young children before they enter into formal school. It was observed to help in cognitive development of children at the early grades of primary education and had a strong bearing on

attendance and participation of children once they enter primary school. The importance of pre-school education had also been emphasised in India. The Kothari commission report (1966) and the National Policy of Education (1968, 1986 and 1992) recommend the need and importance of early childhood care and education.

In addition to stressing the importance of preschool education for typically developing children, professionals have also highlighted the need for preschool education for children with hearing impairment. The recommendations of these professionals lay the basis for providing preschool education for children with special needs.

Pre-School Education for Children with Hearing Impairment

According to Coleman (1995), individuals with disabilities are underserved, do not get enough consideration, and therefore, they do not reach their fullest potential. This includes individuals with hearing impairment also. Karnes and Lee (1978) noted that early identification and appropriate programming is necessary for children to develop their potential. Children were noted to develop at a faster rate during the years from birth to age five. Without early intervention, young children were considered to be at-risk for missing opportunities to learn. Thus, it was considered essential that adequate attention be given to young children to bring out their potential. This issue is addressed by providing pre-school education for children with special needs.

It is well accepted that language input given during the critical period of development helps the child in proper and speedy acquisition of language. The early years in the pre-school period is considered crucial for building a sound foundation for future academic accomplishments of children with hearing impairment. Children with hearing impairment attending pre-school were found to succeed in formal schooling, as they were exposed to skills required for later schooling. This exposure to preschool education was found to equip them for better and successful higher education (Nunes & Moreno, 1998). However, training children with hearing impairment was noted to be not easy as they face difficulties in the learning process because of their language deficit. Children with hearing impairment, admitted into formal schooling without any prior training, were reported to face difficulty and failure in the school. Hence, it was recommended that they should be made ready to get into formal schooling by undergoing quality pre-school education. This was found to

promote inclusive education by increasing enrolment and reducing the vulnerability of children to failure and drop out at later stages of education (Yathiraj, 1995).

Difficulties in scholastic performance have been reported to be seen in different academic subjects including mathematics. Such mathematical difficulties have been seen even in the early years of schooling of children with hearing impairment (Gowramma, 2006).

The challenges that children with hearing impairment encounter when learning arithmetic are noted to be many by Gowramma (2006) on account of the lack of auditory input which restricts exploration in the early years of development. It was observed that problem-solving was particularly difficult for them as they lacked a sound language base which was required to put observations into words and to make predictions. Several decades ago, developmental psychologists like Piaget (1952) and Bruner (1964) have documented that pre-arithmetic skills were learnt informally by children at the early stages of development. Ginsberg (1997) noted that these informal concepts formed the prerequisites for the formal learning of arithmetic in the later stages of schooling. The lag created in the early stages of development was observed to hinder formal learning of arithmetic in school.

Zevenbergen and Powers (2003), who studied the performance of students with hearing impairment on arithmetic word problems, found them to perform poorly. The poor performance was compared to that of hearing peers and the study confirmed that language acquisition was a factor required to learn arithmetic. Stewart and Kluwin (2001) opined that the reasons why mathematics was challenging for deaf students were varied and complex. The reasons ranged from the inability to learn from experiences outside the classroom to utilisation of cognitive abilities in the classroom such as the inability to assign meaning and language to mathematical problems. Earlier, Barton (1995) found that the cognitive concepts which involved specific language related to volume, shape, size, comparisons, measurement and reasoning were particularly difficult for children with hearing impaired to grasp.

Performance of young children with hearing impairment was compared with hearing children on temporal and spatial tasks by Zarfaty, Nunes and Bryant (2004). It was found that the children with hearing impairment performed on par with hearing children in the temporal tasks and outperformed in spatial task. Thus, they concluded that the difficulties of

children with hearing impairment were not consequent to a delay in number representation and hence emphasis on spatial representation has to be given in mathematical instruction.

Pau (1995) analyzed the influence of reading comprehension level on the solution of verbally expressed problems of arithmetic. The results indicated that reading comprehension level was related to the problem-solving ability of the subjects with hearing impairment. In general, the students with hearing impairment were unable to understand verbally presented problem and were hence not able to solve them correctly.

Other researchers have also provided evidence about the lower level of performance in formal arithmetic in children with hearing impairment in comparison with hearing pupils. This trend observed during the 60s (Wollman, 1965) is found to continue to be the same in the present millenum also (Traxler, 2000).

In order to judge the initial success of children with hearing impairment in school in arithmetic, it is necessary to have a school readiness test to assess concepts related to learning arithmetic. This will not only help children but also parents and teachers plan the educational support programs.

Need and importance of the study

From the review of literature, it is evident that learning arithmetic is both difficult and challenging for children with hearing impairment. They are noted to have difficulty in reading and following the instructions before attempting to solve the numerical problems. Children with hearing impairment are integrated into regular schools with the assumption that the children are ready for learning new skills. However, many children with hearing impairment find it difficult to cope with the new skills to be learnt as the pre-requisite skills and concepts required have not been appropriately developed.

In order to determine the preparedness of the child to enter into the formal school, assessment has to be done to know if the pre requisite skills are acquired. Such assessment would help know the present level of performance of a child and also would help in making appropriate decision regarding the educational placement, the types of supports required and referral for special educational services to the children. Though this process is important for all children, it is more important for children with hearing impairment. School readiness test

for children with hearing impairment is essential, as they become instrumental in planning remedial education programs by identifying the broad areas of academic strengths and weaknesses.

Hence, there is a need to assess the readiness of children with hearing impairment for pre-arithmetic skills which is to be acquired during their pre-school training period. This in turn would determine the readiness for formal schooling and also the abilities of children with hearing impairment to learn higher arithmetic skills. There is a dearth of standardised tool to assess the school readiness of a child in India. A school readiness test evaluating environmental studies has been developed by Yathiraj, Gowramma, Malar, Prithi and Vijetha (2008), in the Department of Special Education in the All India Institute of Speech and Hearing, Mysore. This test has been found to be useful while deciding about further educational placement of children. This test however did not tap pre-arithmetic skills. Hence, the study was undertaken with the aim to develop a test for assessing the readiness of children with hearing impairment in pre-arithmetic skills and check its utility by administering the test on typically developing children as well as preschool children with hearing impairment.

METHOD

The study was carried out in two stages. The first stage involved the development of the test material and the second stage dealt with field testing it on typically developing children and children with hearing impairment.

Participants

Two groups of participants were included in the study. Group-I consisted of 100 typically developing children of whom 25 were used for Stage-1 of the study and the remaining 75 were used for Stage-II. Group-II had 37 children with hearing impairment.

The *typically developing group* had children in the age range of 4½ years to 5 years studying in preschool. For Stage-I of the study 10 children were selected from 2 regular schools that had English as the medium of instruction and 15 were selected from 5 regular schools that had Kannada as their medium of instruction. The 75 children selected for Stage-II of the study were from 7 schools with English as the medium of instruction and 5 schools with Kannada as the medium of instruction. From the former, 40 children and from the latter 35 children were tested on the tool designed for the study. All the schools were located in Mysore city.

All the typically developing children had no hearing problem, no history of ear discharge and no other disabilities, as reported by the teacher. Additionally, none of them were found to have any problems with their studies. It was ensured that the children who were selected for the study had been taught in school the mathematical concepts recommended in the syllabus for preschoolers.

The *children with hearing impairment*, aged 5 to 6 years were selected from 4 special schools from Mysore and Bangalore. All the children wore binaural BTE / pseudo binaural body level hearing aids, prescribed by qualified audiologists for more than two years. Only those children who were reported to have no additional disability were selected. The children with hearing impairment were reported to have language levels appropriate for the class in which they were studying. All the children had undergone specialized speech and language training and / or specialized pre-school training for approximately one year.

Test Environment

All testing were carried out in quiet rooms within the school premises that were free from visual and auditory distracters. The rooms were selected such that they were located away from sources of noise and had adequate natural lighting.

Procedure:

Stage I: Development of test material

The development of the material (Stage-I) was carried out in three phases. The phases included

Phase I: Compilation of the test materials

Phase II: Validation of test items with professionals and caregivers

Phase III: Validation of test item on typically developing children.

Prior to testing any child, permission was sought from the caregivers to collect data. The testing of each child was carried out individually.

Phase I: *Compilation of Test Items*

To design the test, the syllabi for mathematical skills followed in 10 regular preschools in and around Mysore were referred to. Multiple syllabi had to be referred to since no standard syllabus was available for preschools. The content in the 10 syllabi that were common were selected to be included in the test.

The compiled test items covers three major areas to assess the pre-arithmetic skills of pre-school children. These included number concepts, fundamental operation and shapes. The *number concept subsection* had 10 tasks that tapped temporal related information (before, after, first, later), spatial information (left, right,) and quantitative information (big, small, more, less, much, greater) along with reading and writing numbers. *Fundamental operation subsection* assessed addition and subtraction skills. The 7 tasks to tap addition skills included adding objects, adding numbers, statement based addition. Similarly, the 4 tasks to evaluate subtraction were subtracting objects, subtracting numbers, statement based subtraction. The *concept* of *shapes* was assessed using 4 tasks that evaluated knowledge of 4 different basic shapes (circle, triangle, rectangle & square). To assess the three subsections

of the tool (number concepts, fundamental operation and shapes), a large number of test items were compiled. For evaluating number concepts, fundamental operation and shapes the number of items were 60, 50 and 20 respectively.

The items to evaluate the above pre-arithmetic skills were selected from age appropriate books and instructional material. Further, the test material was designed such that the stimuli were presented either auditorily (presented orally) or visually (presented as pictures, written information or objects). This was done to tap the performance of children when the stimuli was given both auditory as well as visual modality. For the items that were to be tested visually, the pictures, written material and objects were compiled. There were test items eliciting response either from open set (when the choice for response was not given) or closed set (when choice was provided to respond).

Phase II: *Validation of test items with professionals and caregivers*

Validation of the compiled material was done by getting feedback from 35 professionals in the field. The experts included 10 regular pre-school teachers, 10 primary school teacher, 10 special pre-school teachers and 5 speech and hearing professionals. The teachers / professionals were required to indicate whether the concepts as well as the test items were appropriate or not in relation to the syllabus followed by the schools. Additionally, they had to specify if the vocabulary and concepts were age appropriate. Modifications and suggestions given by the teachers / professionals were incorporated only if more than 10% of them recommended the change.

Phase III: *Validation of the Test Items on typically developing children.*

To validate the developed tool, it was administered on 25 typically developing children studying in 7 different schools. The children were tested individually in quiet rooms, free from distraction. They were seated comfortably prior to the commencement of the evaluation. They were instructed orally regarding what they were expected to do. Breaks were given during the testing, if a child showed any sign of fatigue or restlessness. The children received no feedback as to whether they were right or wrong. Each test item was presented only once. The test items were retained only if more than 80% of the children responded positively. The remaining items were deleted. Using the materials that could be carried out by more than 80% of the children, the test items were finalised.

Table 1: Details of the developed test.

Concept	Test Tasks	Response mode	Response expected	No. of Items	Score per correct Response	Maximum possible score
Number Concept	Count & Write	VO	Write	5	1	5
	Count & Tick the correct number	VC	Tick/Point	5	2.5	2.5
	Write the missing number (Before)	VO	Write	5	1	5
	Write the missing number (After)	VO	Write	5	1	5
	Listen to the statement and answer (before)	AO	Oral	5	1	5
	Listen to the statement and answer (after)	AO	Oral	5	1	5
	Match the number to number	VC	Pointing	5	2.5	2.5
	Match the number to word	VC	Pointing	5	1	5
	Listen and point the number	AC	Pointing	5	1	5
	Listen to the number and point the word	AC	Pointing	5	1	5
Fundamental Operation (Addition & Subtraction)	Add the object and write the number	VO	Write	5	1	5
	Addition (statement problems)	VC	Pointing	5	1	5
	Auditory (statement problems)	AO	Oral	5	1	5
	Auditory (Statement problems)	AC	Pointing	5	1	5
	Subtraction (statement problems)	VC	Pointing	5	1	5
	Auditory (statement problems)	AO	Oral	5	1	5
	Subtraction (statement problems)	AC	Pointing	5	1	5
Shapes	Colour the shapes	VC	Colouring	4	1	4
	Name the shapes	VO	Oral	4	1	4
	Show the correct shapes	AC	Pointing	4	1	4
	Draw the following	AO	Drawing	4	1	4
Total items / marks				101		96

Note. *Total score for: Visual open (VO) = 24; Visual closed (VC) = 24; Auditory open (AO) = 24; Auditory closed (AC) = 24*

Stage II: Field testing of developed test material

The developed test was field tested on 75 typically developing children and 37 children with hearing impairment who met the participant selection criteria. Each child was tested independently after being seated comfortably in a distraction free room. The child was seated in front of a table having appropriate height for primary school children. The tester was seated at a distance of 1 meter from the child, on the opposite side of the table. The test material was placed in front of the child.

The instructions for each task were provided orally, one at a time, in the order of the tasks mentioned in Table 1. The instructions were provided using a vocal effort that is typically used when talking to a person seated 1 meter away. Along with the instruction, the visual material, appropriate for the task, was placed in front of the children, on the table. The instruction for the following task was given only after giving adequate time for the children to complete the previous task. The instructions for a particular task were repeated once, using the same constant vocal effort, if the children indicated that they were unable to understand what was said. It was ensured that when a particular task was being evaluated, the child could not view the material for the other tasks. No help was provided by the tester to carry out the tasks. If the children were unable to perform a particular task after the repetition of the instruction, evaluation of the next task was carried out. The children received no feedback as to whether their responses were correct or wrong.

While testing the children with hearing impairment, it was initially established that they wore their prescribed hearing aids that were working. The majority (29) of the children wore binaural BTEs. The remaining children (8) wore pseudobinaural body level hearing aids. Children who depended on speech reading were allowed to watch the tester when the instructions were given, in addition to listening to the instructions.

Depending on the task, the responses from the children varied as indicated in Table 1. The responses, for tasks that required oral or pointing responses from the children, were noted by the tester on a response sheet. Depending on the speed at which a child responded, the test time ranged from 30 minutes to 45 minutes.

Scoring: The score for the responses varied depending on the simplicity of the tasks. In general, a correct response was given score of 1 and an incorrect response a score of 0. Only two of the tasks (‘Count and tick the correct number’ & ‘Match the number to number’)

were assigned a score of 0.5 for a correct answer and 0 for an incorrect answer. Lower scores were assigned to these tasks due the simplicity of the tasks compared to the other tasks. Details regarding the scores to be assigned to the different tasks are provided in Table 1. The total possible score for the 101 items was 96.

Analyses: The tabulated data were subjected to statistical analyses. Besides obtaining the mean and standard deviation, repeated measure ANOVA, MANOVA and paired t-test were done to determine if there existed any statistically significant difference between the participant groups and the test items.

RESULTS

Analyses were carried out to compare the performance of the two groups of children. One group had children with typical development and another group had children with hearing impairment. Additionally, analysis to compare the performance of the two groups for the two types of questions (open and closed) and questions tapping two sensory modalities (auditory and visual) was also done. Further, performance on the two types of questions and questions tapping two sensory modalities was also compared within each participant group. The data were analysed using repeated measure ANOVA, MANOVA and independent t-test. Mann-Whitney U test was also used to confirm the results of the parametric statistics between the participant groups, as the sample size differed considerably.

I. Comparison of scores between typically developing children with CWHI

a. Comparison of overall performance of typically developing children with CWHI:

Table 2 depicts the mean and standard deviation (SD) of the total test scores for the two groups. It can be seen that the mean score of the typically developing children was higher than that obtained by the children with hearing impairment. Similarly, the SD was lesser in the typically developing group compared to the group with hearing impairment.

Table 2: Mean and SD of the total test scores of the two groups.

Groups	N	*Mean	SD	Lower bound	Upper bound
Typically developing	100	92.6	4.32	77	96
Hearing impaired	37	84.84	9.98	56	96

Note. * *Maximum possible score = 96*

Two-tailed independent t-test was performed to check if the difference in scores was significant. The t-test indicated that there was a statistically significant difference between the typically developing children and the children with hearing impairment [$t(135) = 6.38$, $p < 0.01$] for the overall scores. Since the sample size of the two groups was unequal, the result

of independent t-test was also cross checked with non-parametric Mann-Whitney U test. Similar results were obtained through both the statistical procedures ($z = 4.67$, $p < 0.01$).

b. Comparison of typically developing children with CWHI for questions tapping visual and auditory modalities:

Further, the scores obtained by the two groups of children were categorized based on the sensory modalities that were tapped. The mean and SD of the scores obtained by the two groups of participants for questions that were visual based and auditory based are provided in Table 3. From the table, it can be seen that for the visual based questions the mean scores were almost similar with not much variation in SD between the two groups. In contrast, for the auditory based questions there was a marked difference in the mean scores between the two groups. The SD was also considerably more for the CWHI compared to the typically developing children.

Table 3: Mean and SD of the scores for the visual (visual open & visual closed) and auditory (auditory open & auditory closed) based questions for the two groups

Modality	**Groups**	**N**	***Mean**	**SD**	**Lower bound**	**Upper bound**
Visual	Typically developing	100	47.63	1.32	47	48
	Hearing impaired	37	47.16	2.53	47	48
Auditory	Typically developing	100	45.03	3.76	44	46
	Hearing impaired	37	37.43	8.34	36	39

Note. * *Maximum possible score = 48*

In order to determine how the two participant groups differed from each other for the visual based and auditory based question, MANOVA was done. It revealed that there was a significant difference between the typically developing children and the CWHI for questions tapping the auditory modality [$F(1, 135) = 53.93$, $p < 0.01$]. In contrast, no such difference between the participant groups was seen for the visual based questions [$F(1, 135) = 1.974$, $p > 0.05$]. The results of Mann-Whitney U test confirmed the results of the parametric statistics. As seen in the MANOVA results, a significant difference was noticed between the groups for

the auditory based questions ($z = 5.09$, $p < 0.01$) but not for the visual based questions ($z = 0.51$, $p > 0.05$).

c. Comparison of typically developing children with CWHI for open and closed type of questions:

Table 4: Mean and SD of the scores for the open (visual open & auditory open) and closed (visual open & auditory open) type of questions for the two groups.

Question type	**Groups**	**N**	***Mean**	**SD**	**Upper bound**	**Lower bound**
Open	Typically developing	100	46.65	1.84	41	48
	Hearing impaired	37	41.72	6.65	18	48
Closed	Typically developing	100	46.04	2.90	33	48
	Hearing impaired	37	42.83	3.95	38	48

Note. * *Maximum possible score = 48*

Similar to the earlier analyses, the performance of the typically developing children was better than that of CWHI for the open as well as the closed type of questions. Likewise, the SD was more for the CWHI in both the type of questions. This can be observed from the mean and SD provided in Table-4.

To compare the scores of the open and closed type of questions, MANOVA was done. A significant difference was seen between the two groups for the open [$F (1, 135) = 45.73$, $p < 0.01$] and closed [$F (1, 135) = 26.88$, $p < 0.01$] type of questions. Similar findings were obtained using Mann-Whitney U test where a significant difference between the two groups for the open ($z = -5.18$, $p < 0.01$) and closed type of questions ($z = -4.42$, $p < 0.01$). This non-parametric test was done to confirm the results of the parametric test due to the unequal sample size.

d. *Comparison of stimuli [question type (open & closed) & modality (visual & auditory)] across participant groups*.

To compare the performance of the two participant groups for combinations of the 2 question types (open & closed) as well as modalities (visual & auditory), MANOVA was

used. Additionally, MANOVA results for the 4 variables (visual closed, visual open, auditory open, auditory closed) was cross checked with Mann-Whitney U test since the sample size between the two participant groups was different.

Table 5: Mean, SD and p values for responses to visual open, visual closed, auditory open and auditory closed questions for the two group

Type of question/ modality	**Participant groups**	**N**	**# Mean**	**SD**	**Parametric Stat**			**Non-parametric Stat**	
					F	**df**	**P**	**Z**	**P**
Visual open	Typically developing	100	23.92	0.46	8.30	135	$p < 0.01$	-2.06	$p < 0.01$
	Hearing impaired	37	23.16	2.53					
Visual closed	Typically developing	100	23.71	1.14	2.39	135	$p > 0.05$	-1.77	$p > 0.05$
	Hearing impaired	37	24.00	.000					
Auditory open	Typically developing	100	22.73	1.77	55.96	135	$p < 0.01$	-5.32	$p < 0.01$
	Hearing impaired	37	18.76	4.77					
Auditory closed	Typically developing	100	22.30	2.30	39.64	135	$p < 0.01$	-4.77	$p < 0.01$
	Hearing impaired	37	18.86	3.95					

Note. # *Maximum possible score = 24*

From Table 5 it can be observed that the typically developing children and the children with hearing impairment performed differently. The former group performed significantly differently on open and closed type of questions only when they were visual based questions. However, in the latter group, this difference was not seen for the visual based tasks but difference was seen for the auditory based tasks.

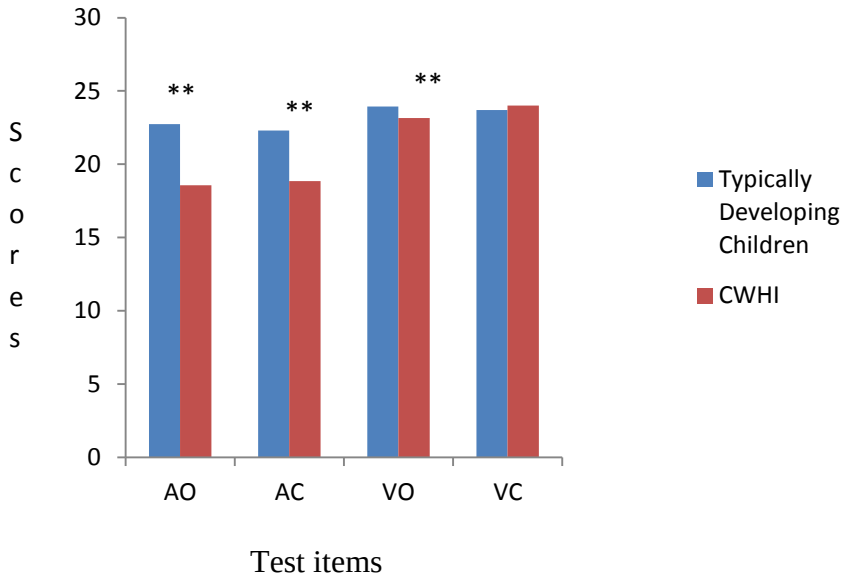

Figure 1: Performance of the typically developing children and children with hearing impairment (CWHI) for the auditory open (AO), auditory closed (AC), visual open (VO) and visual closed (VC) stimuli.

From Figure 1 it is clear that between the two groups there was a marked difference in scores for the auditory based questions. This marked difference was not present for the visual based items.

Table 6: Summary of the comparison between the typically developing children and children with hearing impairment (CWHI) for the different stimuli

	Total score	VO+VC	AO+AC	VO+AO	VC+AC	VO	VC	AO	AC
Typically Developing Vs CWHI	p<0.01	**p>0.05**	p<0.01	p<0.01	p<0.01	p<0.01	**p>0.05**	p<0.01	p<0.01

Note. *VO = Visual open; VC = Visual closed; AO = Auditory open; AC = Auditory closed*

From Table 6 it is clear that the two groups did not differ only for the visual based tasks, especially for the closed type of questions. For all the auditory based tasks, there was a significant difference between the two groups.

II. Comparison of scores within typically developing children and CWHI

Repeated measure ANOVA was carried out to check the main effect within each of the participant groups. With the type (open & closed) and modality (auditory & visual)

combined, there was a significant effect for the typically developing children [$F(1, 99) = 54.85$, $p < 0.01$] as well as the CWHI [$F(1, 36) = 58.87$, $p < 0.01$]. Since there was a significant main effect, t-test was carried out to check the performance type and modalities for each of the participant groups.

a. *Comparison of scores of visual and auditory based questions within each group:*

From Table 7 it can be discerned that *within the typically developing group*, the t-test indicated that there was a significant difference for total visual and auditory tasks. When the visual and auditory questions were sub-categorized as open and closed the performance differed. For the visual tasks, no significant difference was seen between the open and closed question ($p > 0.05$). On the other hand, for the auditory based question there was a significant difference for the open and closed questions.

In the group of *CWHI* there was a significant difference between the total visual and auditory task as well as the visual open and the visual closed task ($p < 0.01$). However, no significant difference was seen for the auditory open and auditory closed tasks ($p > 0.05$).

Table 7: Comparison of open and closed type of questions for visual and auditory based questions in typically developing children and children with hearing impairment.

Groups	**Pairs**	**df**	**T**	**Level of significance**
Typically developing	Visual total Vs. auditory total scores	99	7.15	$p < 0.01$
	Visual open Vs. Visual closed scores	99	1.857	$p > 0.05$
	Auditory open Vs. auditory closed scores	99	2.601	$p < 0.01$
Hearing impaired	Visual total Vs. auditory total scores	36	8.02	$p < 0.01$
	Visual open Vs. visual closed scores	36	2.01	$p < 0.01$
	Auditory open Vs. auditory closed scores	36	0.68	$p > 0.05$

Note. *Visual total = Visual open + Visual closed;*
Auditory total = Auditory open + Auditory closed

b. *Comparison of scores of open and closed type of questions within each group:*

From Table 8 it can be observed based on the t-test that within each group the open and closed types of questions were significantly different. This was seen for the total scores of the open and closed type of questions as well as for the visual based and auditory based question.

Table 8: Comparison of visual and auditory based questions for open and closed type of questions in typically developing children and children with hearing impairment.

Groups	**Pairs**	**Df**	**T**	**P**
Typically developing	Open total– Closed total scores	99	2.63	$p < 0.01$
	Open visual – Open auditory scores	99	6.56	$p < 0.01$
	Closed visual– Closed auditory scores	99	6.70	$p < 0.01$
Hearing impaired	Open total – Closed total scores	36	1.24	$p < 0.01$
	Open visual – Open auditory scores	36	7.49	$p < 0.01$
	Closed visual – Closed auditory scores	36	7.92	$p < 0.01$

Note. *Open total = Open visual + Open auditory;*
Closed total = Closed visual + Closed auditory

Table 9, provided below gives an overview of the findings within each of the participant groups. It is clear that the two groups do not function in a similar manner. This difference was present only when combination of modality and type of questions were combined.

Table 9: Comparison of scores within each participant group

	V vs A	**VO vs VC**	**AO vs AC**	**O vs C**	**OV vs OA**	**CV vs CA**
Typically developing	$p < 0.01$	**$p > 0.05$**	$p < 0.01$	$p < 0.01$	$p < 0.01$	$P < 0.01$
CWHI	$p < 0.01$	$p < 0.01$	**$p > 0.05$**	$p < 0.01$	$p < 0.01$	$p < 0.01$

Note. *VO = Visual open; VC = Visual closed; AO = Auditory open; AC = Auditory closed;*
V = VO + VC; A = AO + AC; O = VO + AO; C = VC + AC

DISCUSSION

From the comparison of performance between the two groups of children it is evident that the typically developing children performed significantly better than the children with hearing impairment. This was seen for the total overall scores and for all the auditory based questions. This higher score for the auditory based questions was seen for the total auditory based score as well as when the questions were sub-categorized as auditory open and auditory closed. In both groups the scores dropped for the auditory based questions, but this drop was more prominent for the CWHI. This is evident from the mean scores provided in Table 5.

Similar observations were made in earlier studies by Pau (1995), Traxler (2000) Paul and Quigley (1990), Greenber and Kushe (1989) and Martin (1985). They too observed on the tasks evaluated by them that CWHI performed poorer than normal hearing children.

In contrast, for the visual based questions in the current study, no significant difference was seen for the total score for this section. This suggests that all children in the early stages of their development are dependent more on visual modality for concept formation even if the auditory modality is fully functioning. Irrespective whether children have hearing impairment or not, they acquire the basic pre arithmetic concepts in the same way.

There continued to be no significant difference between the two groups when the visual based questions were given with choices of answers (closed type). However, when the visual based questions were given with no choices (open type) there was a significant difference between the two groups. Further, on the visual-closed task, the CWHI preformed slightly better than the typically developing children (Table 5, Figure 1). This indicated that on visual based tasks with options given, CWHI are able to perform on par with typically developing children.

When the performance within each participant group for the different types of questions and the modalities tapped were compared (Table 9) their difficulties were not found to be similar. As mentioned earlier for the visual and auditory tasks, typically developing children perform equally well reaching the ceiling level under the visual task, both in the open and closed question types indicating their visual learning abilities being highly active. Among the typically developing children, difference for the auditory task was seen for open

and closed type of questions. Though statistically significant, the mean difference is not very striking (Table 5).

The findings of the present study are in consonance with that reported in literature. CWHI were found to outperform the normal hearing young children in informal spatial pre arithmetic tasks by Zarfaty, Nunes and Bryant (2004). Further, Hood and Poole (1971) also observed that closed-set speech identification abilities in individuals with hearing impairment were far better than their open-set responses. They also noted that individuals with hearing impairment did not achieve 100% open-set word perception even when material were presented at sufficient loudness.

From the mean scores given in Table 5 of the present study, it can be seen that when the questions were visual-closed, a ceiling effect was seen in both groups thus resulting in no significant difference between the groups. Though the CWHI obtained similar mean scores for the visual-open and the visual-closed type of questions, the variability was larger for the former. The latter resulted in the participants obtaining perfect scores, thus resulting in no variability. This probably led to the significant difference between the groups only for the visual-open type of questions.

As early as 1971, Erber also reported that CWHI relied on visual cues for comprehension in spite of amplified acoustic cues being provided. This trend continues to be present despite the advances in technology wherein CWHI use digital technology which should have reduced their dependence on visual cues. In the present study, the primary difficulty of CWHI was in the auditory based question. This highlights the need to further stress on providing listening training for CWHI. This would help them cope in a regular school set-up where major mode of learning is through the auditory modality.

From the findings of the present study, it can be inferred that the newly developed pre-arithmetic school readiness test is sensitive to pick-up the difficulties CWHI have in learning pre-arithmetical concepts. The test can be used to detect the specific difficulties in pre-arithmetic concepts that CWHI have. This would enable planning appropriate remedial instruction programmes for CWHI. The test can also be used as a guideline to decide on further educational placement of such children. Further, the developed test can not only throw light on the pre-arithmetic performance of CWHI, but also on the performance of typically developing children. It is suggested that all the subcategories of the test should be administered. This is recommended since the CWHI performed significantly poorer in most

of the categories and sub categories of questions in the test when compared to the typically developing children.

CONCLUSION

The comparison of performance of the two groups (typically developing & CWHI) for the sensory modality (visual & auditory) and type of questions (open & closed), revealed a statistically significant difference. This difference was seen for the scores of auditory stimuli, open type of questions and closed type of questions. The performance of the two groups did not differ significantly only for the visual based stimuli. Further, the performance of the two participant groups did not differ significantly only for the closed type of questions presented through the visual modality.

When the comparison of scores were done within each of the participant groups, the pattern of difficulty varied for the categories studied. This indicated that the level of difficulty varied depending on whether they had hearing impairment or not.

Thus, it can be construed from the finding of the present study that though CWHI wear state-of-the-art hearing devices to compensate for their hearing loss, they continue to have difficulty in carrying out auditory based activities. Hence, while planning auditory based activities, special care is required to make the signals audible to the CWHI. Additionally, listening training is recommended to enhance their listening skills.

The visual based items are found to be easy for both typically developing children and the CWHI. This can be a guideline to professionals and practitioners to include visual based activities in the early years of development for all children.

The newly developed pre-arithmetic school readiness test is found to be sensitive to tap the difficult areas of pre-arithmetical concepts that CWHI have. The test helps in planning appropriate remedial instruction programmes for CWHI and in selecting educational placement. The developed test highlights the pre-arithmetic performance of CWHI as well as that of typically developing children. The test would also serve as a guideline to provide specific activities for training children in early intervention centers and pre-schools.

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Pre-Arithmetic School Readiness Test for Children with Hearing Impairment (PA-SRT-HI)

Yathiraj A., Gowramma I.P., Nair P., Vijetha P., and Varun A.

Developed as a part of an ARF project titled 'Pre-Arithmetic School Readiness Test for Children with Hearing Impairment'

2012

Test description:

The 'Pre-Arithmetic School Readiness Test for Children with Hearing Impairment (PA-SRT-HI) has been developed to assess basic arithmetic concepts in children with hearing impairment prior to them being admitted into Grade-I. The test is designed for children aged 5 to 6 years having hearing impairment with age appropriate language skills. The children should have been taught communication using speech through the auditory modality. They should have appropriate listening devices such as hearing aids / cochlear implants. Those children who get minimal benefit from their auditory abilities, the test can be administered through auditory-visual mode (with speech reading).

The test assesses three major areas of pre-arithmetic skills. These include number concepts, fundamental operation and shapes. The *number concept subsection* had 10 tasks that tapped temporal related information (before, after, first, later), spatial information (left, right) and quantitative information (big, small, more, less, much, greater) along with reading and writing numbers. *Fundamental operation subsection* assessed addition and subtraction skills. Basic understanding of primary shapes is also assessed.

General instructions to the evaluator:

The test should be carried out in a quiet room, free from auditory and visual distractions, with the child seated comfortably. It should be administered auditorily and visually as indicated against each task. Objects are to be used wherever indicated in a test task. Provide the instructions to child using a natural vocal effort and visual expressions that are typically used while communicating to a child 1 meter away. The instructions can by repeated once, if not understood by the child. ***The instruction to the child for each task is provided along with the task in the test. Whenever required, instructions to the evaluator are given within brackets.***

Additional help like prompting and examples are not to be given while evaluating the child. Give adequate time for the child to respond before presenting the next test item. The child is not to be given any feedback as to whether the response is right or wrong. The items are to be scored as mentioned against each test task.

TEST ITEMS

I Number Concepts **Score**

1. Count & Write (V O) **(1 X 5)**

Instruction: *Count the pictures and write how many are there.*

a. 

_____

b. 

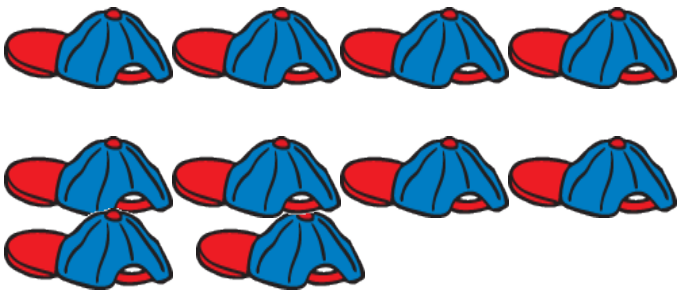
_____

c. 

_____

d. 

_____

e. 

_____

2. Count & Tick (✓) the Correct Number (V C) (0.5 X 5)

Instruction: *Count the pictures and tick (✓) the correct number.*

a. 

5 3 6 4

b. 

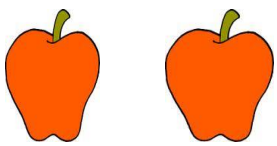
7 8 3 6

c. 

2 1 4 3

d. 

0 2 1 3

e. 

1 6 4 2

3. Write the missing numbers (VO) **(1 X 5)**

Instruction: *Write the number that comes after the number.*

a) _____ 5 _____

b) _____ 8 _____

c) _____ 6 _____

d) _____ 2 _____

e) _____ 9 _____

4 . Write the missing numbers (VO) **(1 X 5)**

Instruction: *Write the number that comes before the number.*

a.) _____ 6 _____

b) _____ 8 _____

c) _____ 1 _____

d) _____ 7 _____

e) _____ 2 _____

5. Listen to the statement and answer (A O) **(1 X 5)**

Instruction: *Listen to what I say and answer.*

a. What comes before five?

b. What comes before two?

c. What comes before four?

d. What comes before eight?

e. What comes before nine?

6. Listen to the statement and answer (A O) **(1 X 5)**

Instruction: *Listen to what I say and answer.*

a. What comes after six?

b. What comes after three?

c. What comes after one?

d. What comes after four?

e. What comes after five?

7. Match the numbers (VC) **(0.5 X 5)**

Instruction: *Draw a line to match the number under 'A' with the number under 'B'.*

	A	**B**
a.	**2**	**6**
b.	**9**	**5**
c.	**6**	**9**
d.	**5**	**4**
e.	**4**	**2**

8. Match the number with the word (VC) **(1 X 5)**

Instruction: *Draw a line to match the number with the word.*

a)	**3**	**Four**
b)	**8**	**One**
c)	**4**	**Three**
d)	**7**	**Eight**
e)	**1**	**Seven**

9. Listen and point to the number (AC) **(1 X 5)**

Instruction: *Show the number that I say. (The tester should change the order of the numbers while saying them).*

a. 1

b. 8

c. 7

d. 4

e. 6

10. Listen to the number and point to the word (AC) **(1 X 5)**

Instruction: *Show the word that I say. (The tester should change the order of the words while saying them).*

a. Three

b. Nine

c. Five

d. One

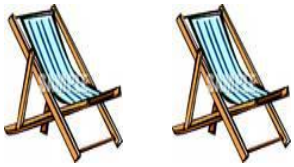
e. Seven

II. FUNDAMENTAL OPERATIONS

A. Addition (1 X 5)

1. Add the pictures and write the number (V O)

Instruction: *Add the pictures and write the answer.*

a)  +  ___

b)  +  ___

c)  +  ___

d)  +   

e)  +  ___

2. Addition (VC) **(1 X 5)**

Instruction: *Look at what I have then listen and answer. (The tester should show the objects as per the test item in his/her hand. The choice of answers should be shown in two flash cards)*

a) I have two pens. Mother gave me two more.
Do I have four or five pens?

(*Information on two cards:* 4 5)

b) I have six pencils. My friend gave me two more.
Do I have eight or seven pencils?

(*Information on two cards:* 8 7)

c) I have one doll. Your class teacher gave me two more.
Do I have three or four dolls?

(*Information on two cards:* 3 4)

d) I have four crayons. Smitha gave me four more crayons.
Do I have seven or eight crayons?

(*Information on two cards:* 7 8)

e) I have three chocolates, and I received two more from our class teacher.
Now do I have three or five chocolates?

(*Information on two cards:* 3 5)

3. Addition (A O) **(1 X 5)**

Instruction: *Listen to what I say and give the answer.*

a) There are two buttons and one more button is added. How many buttons are there together?

b)You have six flowers and one more flower was given to you? How many flowers are there together?

c)There are three oranges in the basket and five more oranges were added. How many oranges are there in the basket?

d) Your teacher gave three stars and your mother gave you two stars. How many stars have you got?

e) You have five pencils at home; uncle gave you one more pencil. How many pencils you have?

4. Addition (AC) **(1 X 5)**

Instruction: *Listen at what I say and answer. (The tester should read the statements and the choice of answers should be shown in two flash cards)*

a) I have six marbles. Raju gave me two more marbles.
Do I have nine marbles or eight marbles with me now?

(*Information on two cards:* 9 8)

b) I have four leaves. Smitha gave me one more leaf.
Do I have seven or five leaves with me?

(*Information on two cards:* 7 5)

c) I have three rings. I received two more rings from Ramesh.
Do I have five rings with me or four rings with me?

(*Information on two cards:* 5 4)

d) I have five match sticks. I received three match sticks from your class teacher.
Do I have seven match sticks or eight match sticks with me?

(*Information on two cards:* 7 8)

e) I have two colour pencils. I received four more colour pencil from Lohith.
Do I have seven colour pencils or six colour pencils now?

(*Information on two cards:* 7 6)

B. Subtraction

1. *Subtraction* (VC) **(1 X 5)**

Instruction: *Look at what I have then listen and answer.* **(***The tester should show the objects as per the test item in his/her hand. The choice of answers should be shown in two flash cards)*

a) I have six chocolates. I gave two chocolates.
Do I have four or three chocolates remaining with me?

(*Information on two cards:* 4 3)

b) I have three erasers. I gave one eraser to my friend.
Do I have two erasers or three erasers remaining with me?

(*Information on two cards:* 2 3)

c) I have five notebooks. I gave two notebooks to Rajesh.
Do I have four note books or three note books leftover with me?

(*Information on two cards:* 4 3)

d) I have six pebbles. I gave four pebbles to class teacher.
Do I have two or four pebbles remaining with me?

(*Information on two cards:* 2 4)

e) I have eight lollypops with me. I gave three lollypops to Ramesh. Do I have four or five lollypops with me now?

(*Information on two cards:* 4 5)

2. Subtraction (A O) **(1 X 5)**

Instruction: *Listen to what I say and give the answer.*

a) You have three chocolates. You gave me two chocolates. How many chocolates do you have?

b) Mummy gave you four mangoes. You ate one mango. How many mangoes are remaining?

c) You have four cakes; you gave one cake to daddy. How many cakes are with you?

d) You have five pencils. Your brother took four pencils. How many pencils are remaining with you?

e) Your friend had six pens. He gave two pens to you. How many pens are with your friend?

3. Subtraction (options should be shown in cards) (AC) **(1 X 5)**

Instruction: *Listen at what I say and answer. (The tester should read the statements and the choice of answers should be shown in two flash cards)*

a) I have five roses with me. If I give two roses to Rajesh, do I have two roses or three roses left with me?

(*Information on two cards:* 2 3)

b) I have eight peppermints with me. If I give three peppermints to your class teacher, do I have five or four peppermints remaining with me?

(*Information on two cards:* 5 4)

c) I have four buttons with me. If I give two buttons to Ramesh, do I have one or two buttons with me ?

(*Information on two cards:* 1 2)

d) I have six stars with me. If I give three stars to Vinod, do I have four stars or three stars with me?

(*Information on two cards:* 4 3)

e) I have five balls with me, if I give four balls to Rajesh, do I have one ball or three balls left with me?

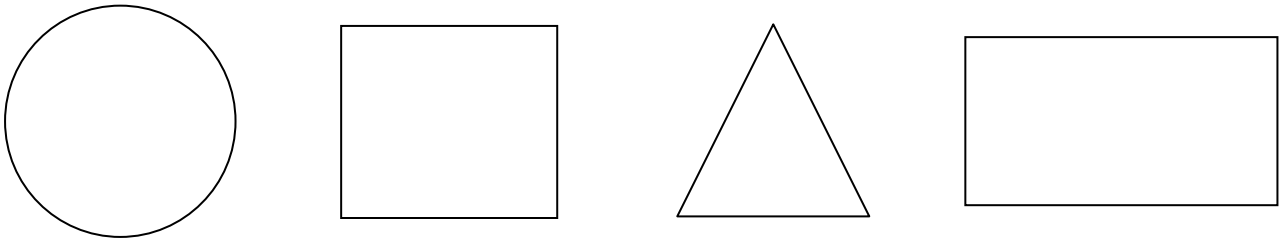
(*Information on two cards:* 1 3)

III. Shapes (V C)

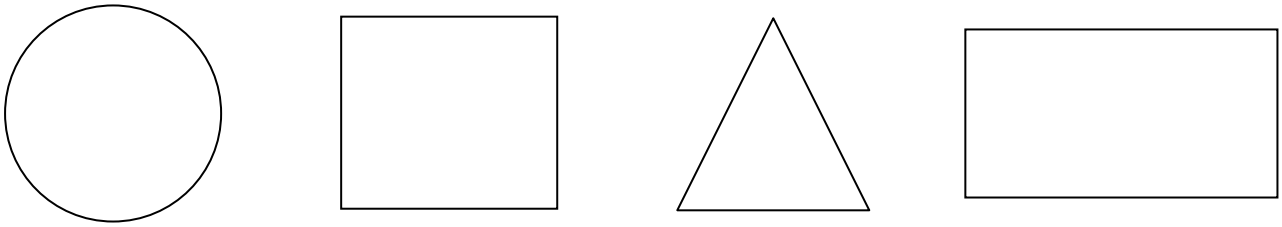
1. Colouring of shapes (1 X 4)

Instruction: *(The tester should read the instructions as given per item, given below)*

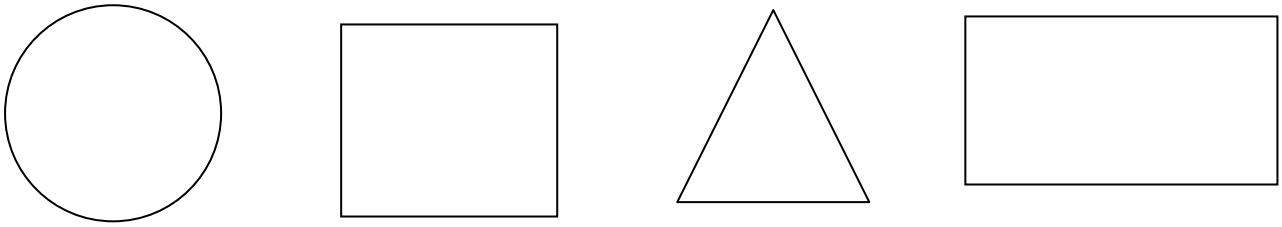
a. Instruction: *Colour the Circle*



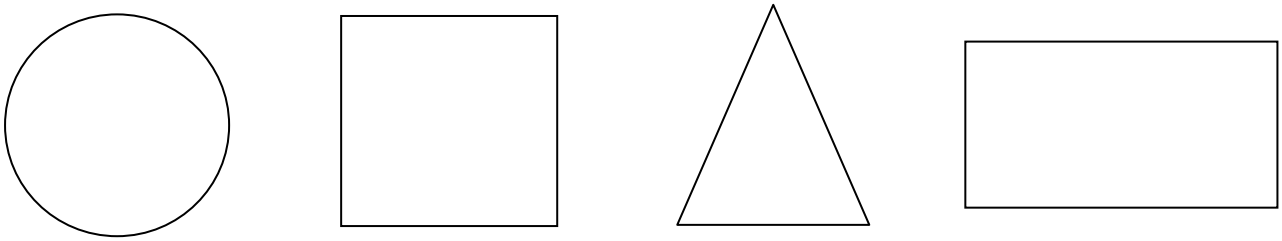
b. **Instruction:** *Colour the Triangle*



c. **Instruction:** *Colour the Rectangle*

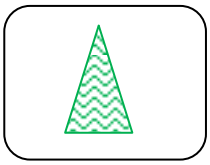


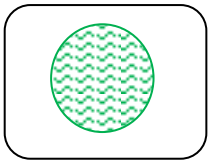
d. **Instruction**: *Colour the Square*

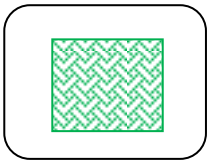


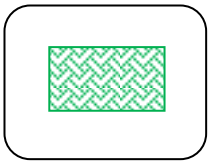
2. Name the shape (VO) **(1 X 4)**

Instruction: *What is this shape? (Show a flash card with one of the shapes and the child has to name it. Only one shape should be given to the child at a time)*

a)  *(Triangle)*

b)  *(Circle)*

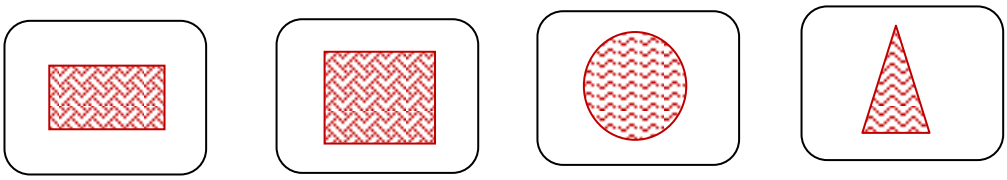
c)  *(Square)*

d)  *(Rectangle)*

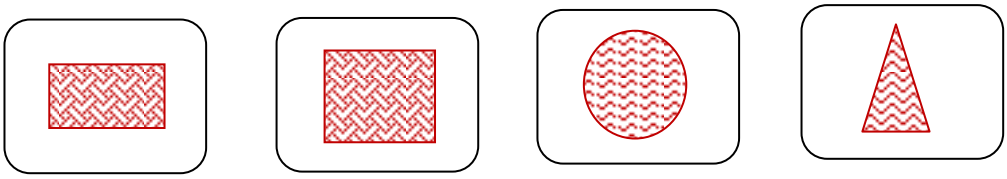
3. Identification of shapes (AC) **(1 X 4)**

Instruction: *Show the shape I say. (The four shapes in the four flash cards should be placed in front of the child. The child should point to the shape said).*

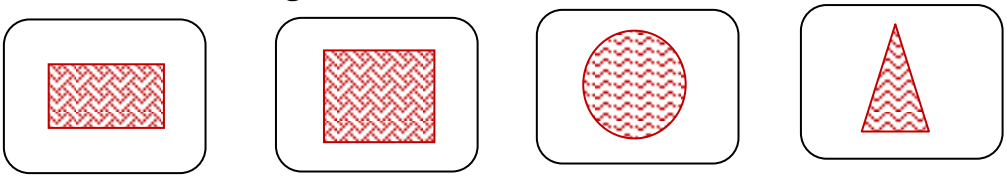
a) Show me the circle.



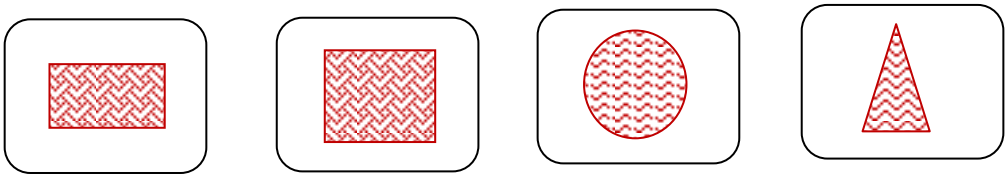
b) Show me the square.



c) Show me the rectangle.



d) Show me the triangle.



4. Drawing of shapes (AO) **(1 X 4)**

Instruction: *Draw the shape I say.*

a) Draw a triangle. _____

b) Draw a rectangle. _____

c) Draw a square. _____

d) Draw a circle. _____

Pre-Arithmetic School Readiness Test for Children with Hearing Impairment (PA-SRT-HI)

Yathiraj A., Gowramma I.P., Nair P., Vijetha P., and Varun A.

RESPONSE - SCORE SHEET

Name: **Gender:**

Case No: **Age:**

Date of testing:

I. Number concept

1. (VO)		2. (VC)		3. (VO)		4. (VO)		5. (AO)		6. (AO)	
Response	Score	Response	Score	Response	Score	Response	Score	Response	Score	Response	Score
	1		0.5		1		1		1		1
	1		0.5		1		1		1		1
	1		0.5		1		1		1		1
	1		0.5		1		1		1		1
	1		0.5		1		1		1		1

7. (VC)		8. (VC)		9. (AC)		10. (AC)	
Response	Score	Response	Score	Response	Score	Response	Score
	0.5		1		1		1
	0.5		1		1		1
	0.5		1		1		1
	0.5		1		1		1
	0.5		1		1		1
						Total =	

II. Fundamental operations

A. Addition

1. (VO)		2. (VC)		3. (AO)		4. (AC)	
Response	Score	Response	Score	Response	Score	Response	Score
	1		1		1		1
	1		1		1		1
	1		1		1		1
	1		1		1		1
	1		1		1		1
						Total =	

B. Subtraction

1. (VC)		2. (AO)		3. (AC)	
Response	Score	Response	Score	Response	Score
	1		1		1
	1		1		1
	1		1		1
	1		1		1
	1		1		1
				Total =	

III. Shapes _____

1. (VC)		2. (VO)		3. (AC)		4. (AO)	
Response	Score	Response	Score	Response	Score	Response	Score
	1		1		1		1
	1		1		1		1
	1		1		1		1
	1		1		1		1
						Total =	

Grand Total =