Journal of Neurological Disorders

Misra and Aikat, J Neurol Disord 2016, 4:6
DOI: 10.4172/2329-6895.1000296

Research Article OMICS International

A Survey of Visual Perceptual Disorders in Typically Developing Children, and Comparison of Motor and Motor-Free Visual Perceptual Training in Such Children

Harshita Misra[1*] **and Ruby Aikat**[2*]

[1]*Samvedna Centre for Rehabilitation, New Delhi, India*
[2]*ISIC Institute of Rehabilitation Sciences, New Delhi, India*

[*]***Corresponding author:*** *Harshita Misra, Occupational Therapist, Samvedna Centre for Rehabilitation, New Delhi, India, Tel: 011 2237 4210; E-mail:* harshita.misra@gmail.com

Ruby Aikat, ISIC Institute of Rehabilitation Sciences, New Delhi, India, E-mail: ruby_aikat@rediffmail.com

Rec date: Jul 26, 2016; **Acc date:** Sep 06, 2016; **Pub date:** Sep 08, 2016

Abstract

Background: Visual perception is the ability to interpret and use what is seen. Interpretation is a mental process involving cognition, which gives meaning to the visual stimulus. Any dysfunction in different components of visual perception may lead to problems in activities of daily living, academics etc. It has been proven that visual perceptual and visual motor skills are different abilities and that test of visual perception and visual-motor integration, measure different skills. Motor free visual perception test-revised (MVPT–R) has been established as a valid and reliable tool for measuring visual perception. Activities like meditation training, mental imagery, visual and tactile cues amongst others can help in improving visual perceptual skills.

Objectives: To find the prevalence of visual perceptual deficits in typically developing children between 5-12 years of age and to compare the effects of motor and motor-free intervention for visual perceptual deficits.

Methods: The study was done in two phases. Phase 1: Survey- The purpose of phase 1 of the study was to find the prevalence of visual perceptual disorders in typically developing children. On a sample of 173 children, MVPT–R was applied and recorded results were analyzed with PASW (version 18.0). The phase 2 of the study (i.e. pre-test post-test experimental study) was done to compare the effects of motor and motor-free visual perceptual training. 30 children who had low scores in MVPT-R assessment were selected for phase 2 of the study. They were divided in 2 groups of 15 children each and received motor and motor-free visual perceptual training respectively for 30 minutes per session, thrice a week for 4 weeks.

Results: The point prevalence was found to be 62.42%. All children showed improvement in visual perceptual skills, but no significant difference was found in motor and motor-free intervention groups even though the means showed a slightly better improvement in motor group. The right handed children performed significantly better than the left-handed children. Also, there was no significant difference in improvement between both the genders. Significant correlation was not found between any variable except 'Perceptual quotient pre-test' and 'Perceptual quotient post-test' in all groups.

Conclusion: Prevalence of visual perceptual deficits is significant in typically developing children. Also, motor and motor-free visual perceptual trainings bring about similar improvements in visual perceptual skills.

Keywords: Perceptual training; Children; Disorders

Introduction

Visual perception is the ability to interpret and use what is seen. Interpretation is a mental process involving cognition, which gives meaning to the visual stimulus [1]. Visual perception could also be defined as total process responsible for the reception and cognition of visual stimuli [2]. There are two components in visual perception which allow us to understand what we are seeing, and are both necessary for functional vision. The visual receptive component is the process of extracting and organizing information from the environment and the visual cognitive component is the ability to interpret and use what is seen [3]. Visual receptive component includes anatomy of eye and oculomotor system; while visual cognitive component includes visual attention, discrimination, memory and visual imagery. Visual discrimination is further divided into object (form) and spatial perception.

Any dysfunction in different components of visual perception may lead to problems in activities of daily living. For example: a child may not be able to differentiate between pen and pencil on his desk if they are partially covered by paper; have difficulty sorting and organizing personal belongings; difficulty in understanding directional language such as 'in', 'out', 'on', 'under', etc., problems with cutting, coloring, construction toys, solving puzzles; difficulty in using a mirror to comb hair, applying toothpaste to the brush, donning and doffing clothes, tying shoes, matching colors etc. [4]. In academics, there can be

interference with acquisition of sight vocabulary. The child cannot recall the beginning of sentence while reading end of it, difficulty to recognize symbols and therefore slow to master alphabets and numbers; letter reversal may ensue, Children who have strong sound-symbol association sense may make dyseidetic errors. Children may have problem in correct letter formation, spelling, mechanics of grammar, punctuation and capitalization, and formulation of sequential flow of ideas necessary for written communication [4].

In the previous studies it has been proven that visual perceptual and visual motor skills are different abilities and that test of visual perception and visual-motor integration, measure different skills [5]. Standardized assessments currently and frequently used by Occupational Therapy practitioners in school setting for measuring visual perception include Motor-Free Visual Perception Test-Revised (MVPT–R), Developmental test for Visual Motor Integration (VMI), Bender Visual Motor Gestalt test, Test of Visual Perceptual Skills (TVPS) and Developmental Test of Visual Perception (DTVP). Test of Pictures, Forms, Letters, Numbers, and Spatial Orientation by Gardner in 1992, Developmental Test of Visual Perception by Hammill, Pearson and Voress in 1993, Subtests of the Test of Visual-Perception Skills by Gardner in 1982 [6-8].

Motor-Free Visual Perception Test-Revised (MVPT–R) has been established as a valid and reliable tool for measuring visual perception [9].

Theoretically, approaches to therapy could be divided in developmental or compensatory approaches. Activities should illustrate both the approaches, for example if classroom materials are adapted so that print is larger and less visual information is present – it is compensatory approach; the child might be better able to use visual perceptual skills with resulting improvement in those skills (developmental approach). In pre-school or kindergarten Occupational therapist can help teachers organize classroom activities to help children develop readiness skills needed for visual perception. e.g. child might benefit from tactile input to help learn shapes, letters, and numbers. Letters can be formed with clay, sandpaper, beads or in pudding etc. Manual activities of drawing or manipulating play dough or clay encourage the eyes to view the movements involved. Simultaneous hand and eye movements construct internal representations of objects and serve the function of object recognition. Using pictures from magazines, the therapist may remove an important part of picture and ask student to identify what part is missing. Drawing, painting and other art and craft activities encourage exploration and manipulation of visual forms. Activities should be analysed and then selected according to child's needs, rather than according to his age group [4]. Activities like meditation training, mental imagery, visual and tactile cues amongst others can help in improving visual perceptual skills.

In the present study an attempt is being made to find out if a significant number of normal school going children have visual perceptual deficits as it would require an early screening and intervention in entry level school so as to prevent manifestations of these deficits into major problems in academics and other activities of daily living. As has been reported in previous studies majority of intervention techniques being implemented for management of visual perceptual deficits require the recipient to participate in various visual-motor tasks; in the second phase of the study a comparison in motor and motor-free intervention strategies is done to see whether motor-free activities if used solitarily bring about similar improvement in visual perceptual skills, when compared to visual-motor activities.

Methods

The study was conducted in two phases: Study design of Phase 1 of the study was survey, to identify the prevalence of visual-perceptual disorders in typically developing children; and Phase 2 was a pre-test post-test experimental design. The complete procedure of the study is shown in flow-chart 1.

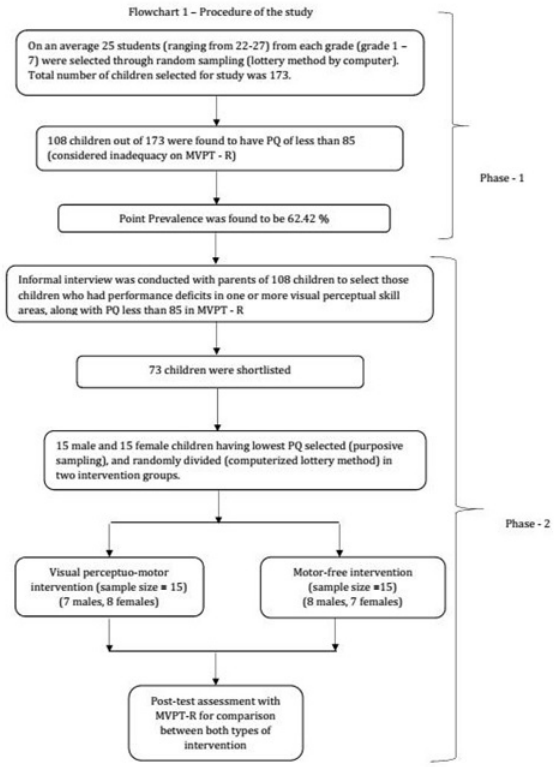
Phase 1

Phase 1 of the study was conducted in a normal mainstream school. The consent for participation in research was taken from the school and the parents of children. Considering it was the pilot study, a smaller sample size was decided upon to be included in the study. Through random sampling (Lotter0079 method through computer), 173 typically developing children from school were selected. Independent variables were age and gender of the child; and dependent variable was score on MVPT-R.

On an average 25 students from each grade (grade 1-7) were selected. The inclusion criteria were age between 5-12 years, both the genders with either normal or corrected vision. Children with history of trauma to head during pre-, peri- or post-natal period, any other visual problem (e.g. field defects), or any other apparent neurological or orthopedic condition interfering with visual perception skills were excluded from the study. Withdrawal criteria were long absenteeism from school due to any reason during the course of the study. Motor-Free Visual Perception Test-R was applied on them. MVPT–R has 5 visual domains – visual discrimination, visual figure-ground, visual memory, visual closure and visual spatial. It contains 40 items. Studies have found MVPT and DTVP to show best clinimetric data amongst tests measuring visual perception [10]. MVPT–R provides two types of normative information, perceptual quotient (PQ) and perceptual ages. Perceptual quotient of 85 or less is considered to be an inadequacy on the test. [11]. Results were recorded and statistical analysis was done using one sample t-test to find out the prevalence of visual perceptual deficits and independent sample t-test to compare the prevalence between genders (male and female) and handedness (left and right handed).

Phase 2

All the children having perceptual quotients (as per MVPT-R) of 85 or less were selected from the sample of phase 1. As per the scale, a score of 85 or less denotes inadequacy on the test. This new sample had 108 children (63 males and 45 females). From this sample, through an informal interview with parents and teachers, those children were selected who had shown deficits in visual perceptual skill areas (in academics such as reversals in handwriting, dyseidetic errors in spellings, copying from blackboard or other areas in activities of daily living such as difficulty in cutting, coloring or constructing activity, tying shoe laces, difficulty using mirror to comb hair, difficulty in catching and throwing etc.). This was done to ensure that the children who had scored less than 85 on MVPT-R also had associated perceptual deficit related issues in their academic and other activities of daily living performances. From this sample, 15 male and 15 female children were selected, through purposive sampling, who had lowest PQ on MVPT-R, and were further divided (randomly using lottery method by computer) into two groups of 15 children each [(group 1: 7 males, 8 females) (group 2: 8 males, 7 females)].



Flow-chart 1: Procedure of study.

Group 1 received visual perceptuo-motor training and group 2 received motor-free visual perceptual training. From the various available data regarding the best possible therapy sessions, a session of 30 min, thrice a week for four weeks can bring about significant improvement in visual perception [8].

Intervention protocol included activities like beads, play dough, blocks, magnetic forms, drawing and painting activity, jigsaw puzzles etc. for Group 1 (visuo-perceptuo-motor training). While Group 2 (motor-free visual perceptual training) participated in activities incorporating verbal responses – what's different, recognizing shapes, identifying partially hidden objects etc. All the activities were graded and intervention focused respectively on the same component of visual perception for both groups. The protocols for both the groups, from day 1 to day 12 were pre-decided, a sample of which has been given in Appendix A.

Intervention protocol was of half an hour, thrice a week for four weeks for both groups. Therapy was provided in groups of five children each. At the end of four weeks, MVPT-R was re-applied to see the improvement in visual perceptual skills in both the groups. Results were then further analyzed with PASW (version 18.0). Independent sample t-test and pearson's correlation coefficient were used for analysis.

Results

Phase 1

Total number of subjects were 173 (112 males and 61 females) (22 left handed and 151 right handed); age range 5.0 – 11.6 yrs. Out of 173 children, 108 children had a PQ less than 85 including 63 males and 45 females. Accordingly, the point prevalence was found to be 108/173 i.e. 0.6242775 (62.42%). To see if the prevalence was statistically significant, one sample t-test, with 85 as test value, was done, as shown in Table 1.

	Test Value = 85			
	T	**df**	**Significance (2-tailed)**	**Mean Difference**
PQ	-3.986	172	0.000	-6.035
One sample t-test to see if the prevalence is statistically significant				

Table 1: One sample t-test.

By using independent samples t-test, difference in the scores of MVPT-R between males and females was found out. Significance was 0.113, which was higher than the p-value of 0.05, thus difference between males and females' MVPT–R scores was not significant. Similarly, using independent samples t-test it was found that right handed children had significantly better performance on MVPT–R than left handed (mean value of PQ for right-handed children was 80.62 whereas mean value of PQ for left handed children was 67.59).

Phase 2

Total number of subjects were 30 (15 males and 15 females); they were divided into two groups according to the type of intervention given: perceptuo-motor (8 females and 7 males) (3 left handed and 12 right handed), and motor-free (7 females and 8 males) (15 right handed). Age group was 5.0 – 11.6 yrs. Descriptive statistics of participants of phase-2 of study are shown in Table 2.

	N	**Minimum**	**Maximum**	**Mean**	**Standard Deviation**
Age	30	5.6	11.6	9.267	2.0297
pre-test Perceptual Quotient	30	55	84	64.30	10.541
post-test Perceptual Quotient	30	70	112	86.93	12.348
Valid N (list-wise)	30				
Descriptive statistics of participants of phase-2 of study					

Table 2: Descriptive statistics.

	t-value	**Df**	**Significance (2-tailed)**
post-test PQ-pre-test PQ	28.441	29	0.000
Paired sample t-test between pre-test and post-test scores of the whole sample			

Table 3: t-test.

Paired t-test was done to compute the difference between pre-test and post-test scores of the whole sample as shown in Table 3.

This indicates that there was a significant improvement in visual perceptual skills in the whole sample.

Mean and standard deviation for improvement in each intervention group is shown in Table 4. Comparison between motor and motor-free intervention groups as per improvement of visual perceptual skills was computed using independent samples t-test as shown in Table 5. (Total sample =30).

Intervention		N	Mean	Std. Deviation	Std. Error Mean
post-pre	Motor	15	21.33	3.716	0.959
	Motor-free	15	21.33	3.716	1.096
Individual intervention group statistics					

Table 4: Group statistics.

	Levene's Test for Equality of Variances	t-test for Equality of Means							
Post-Pre Equal variances assumed Equal variances not assumed	F-Value	Significance	t-value	Degree of freedom	Significance (2-tailed)	Mean Difference	Standard Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
	0.617	0.439	0.092	28	0.928			-2.851	3.118
			0.092	27.517	0.928			-2.853	3.120
Independent sample t – test to compute improvement in individual intervention group.									

Table 5: t-test.

The results show that no significant difference exists between improvement in both the groups; in other words, perceptuo-motor and motor-free intervention are equally beneficial for improving visual perceptual skills.

Comparison between improvements in both genders was done using independent samples t-test. The values were not significant at $p \leq 0.05$, indicating that no significant difference exists in the improvement in both groups.

Comparison between improvements in both age groups (5.0-9.0 yrs and 9.1-11.6 yrs) was calculated using independent samples t-test. The values were not significant at $p \leq 0.05$ level, indicating that no significant difference exists in improvement in both groups.

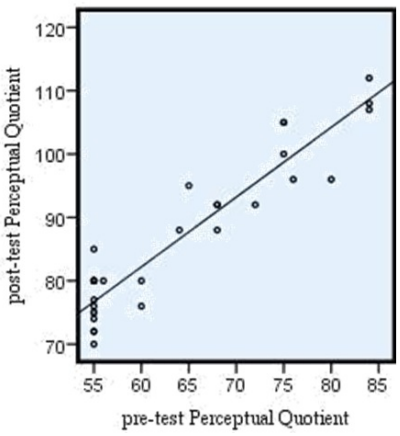
Correlational analysis was done for the whole sample using Pearson's correlation coefficient between 'age', 'perceptual quotient pre-test', 'perceptual quotient post-test' and 'perceptual quotient post – pre'. Correlation was not found to be significant between 'age' and 'PQ', indicating that no relationship exists between 'age' and 'perceptual quotient'. However, significant correlation was found between 'perceptual quotient pre-test' and 'perceptual quotient post-test' as shown in Table 6.

		Age	pre-PQ	post-PQ	post-pre PQ
Age	**Pearson Correlation**	1	0.007	0.075	0.142
	Sig. (2-tailed)		0.972	0.692	0.453
	N	30	30	30	30
pre-PQ	**Pearson Correlation**	0.007	1	0.940**	-0.098
	Sig. (2- tailed)	0.972		0.000	0.607
	N	30	30	30	30
post-PQ	**Pearson Correlation**	0.075	0.940**	1	0.160
	Sig. (2-tailed)	0.692	0.000		0.399
	N	30	30	30	30
post-pre PQ	**Pearson Correlation**	0.142	-0.098	0.160	1

	Sig. (2-tailed)	0.453	0.607	0.399	
	N	30	30	30	30
**Correlation is significant at the 0.01 level (2-tailed).					
Correlational Analysis between 'age', 'perceptual quotient pre-test', 'perceptual quotient post-test' and 'perceptual quotient post–pre'.					

Table 6: Correlation analysis.

Scatter graph of correlation between 'perceptual quotient pre-test' and 'perceptual quotient post-test' is shown in graph 1.



Graph 1: Scattergram showing relationship between pre-test PQ and post-test PQ.

Pearson Correlation (2-tailed) was applied to identify whether any relationship exists between ages and perceptual quotients in motor-free group. Correlation was found to be not significant indicating that no relationship exists between ages and perceptual quotients in motor-free group. Significant correlation was found between "perceptual quotient pre-test" and "perceptual quotient post-test". Pearson Correlation (2-tailed) was applied to identify whether any relationship exists between ages and perceptual quotients in age group (5.0-9.0 yrs). Correlation was found to be not significant indicating that no relationship exists between ages and perceptual quotients in age group (5.0-9.0 yrs). Significant correlation was found between "perceptual quotient pre-test" and "perceptual quotient post-test". Correlation was not found to be significant indicating that no relationship exists between ages and perceptual quotients in age group (9.0-11.6 yrs). Significant correlation was found between "perceptual quotient pre-test" and "perceptual quotient post test."

Discussion

The results of phase 1 study showed that the prevalence of visual perceptual deficits in the given sample was significant.

However, significant difference was not found in male and female children. This result is in concurrence with study done by Marcia CL, in which it was said that gender differences arise only on some types of spatial ability and not all [9]. Similar results were also found by Doreen Kimura in 1969. They reported no difference in visual perceptual abilities between males and females and said that although no clear gender differences in the neural representation of visuo-spatial ability had been reported, there were persistent reports that males surpassed females in over-all visuo-spatial ability [6].

The results also showed that in left and right handed children, a statistically significant difference existed. Right handed children performed significantly better than the left-handed children. These results are in contradiction to the study by Doreen Kimura, 1969, in which it was shown that there was a greater contribution of the right posterior region of the brain to visuo-perceptual ability, thus deducing that the left handed children would perform better than the right handed, in terms of performance on tasks of visuo-spatial abilities [6]. The reason for a contradictory result being found in this study could be the unequal proportion of left handed and right handed children, right handed (151) being much more than the left handed (22).

In phase 2 of the study, comparison between pre and post test scores of all children were done using paired t-test and a significant improvement was seen in both the groups. This is in accordance with a study done by Tartaglia in 2009, where both motor and motor-free activities have been shown to bring about improvements in visual perception. It was shown that when observers train without the relevant stimulus feature but instead imagine it, performance improves i.e. even in the absence of a physical stimuli (motor-free task), perceptual learning could be achieved [12,13].

Comparison between difference of pre and post scores with motor and motor-free intervention groups was done; and it was found that there was no significant difference in improvement between both the groups, even though the means showed a slightly better improvement in motor group. Considering that minimal clinically important difference (MCID) is not established for MVPT-R, it could not be said whether the improvement was clinically significant or not. However, as per teachers' interview it was seen that all the children who were part of phase 2 of the study showed improvement in their academics.

In the study by L. Grigorieva et al. (1996) geometrical figures, and images from natural environment varying in colour, contrast, size, orientation, shape (similar motor and motor-free activities as used in this study) had been used to produce improvement in visual perceptual skills [14].

Considering that both motor and motor-free interventions bring about improvement in visual perceptual skills, and visual motor intervention only gives slightly better results than motor-free intervention and that difference is not statistically significant, in children with physical disabilities, motor-free intervention could be used to bring about improvement in visual perceptual skills and there is no need to completely rely on visual motor integration activities.

There was also no significant difference in improvement seen between both the genders. Both male and female children showed similar improvements. This could be attributed to the fact that neuro-

physiologically there is no difference in the pathways for visual perception in males and females [6,12].

However, since the sample for phase 2 of the study were randomly selected, only a small percentage of left handed children had been included in the sample, thus rendering it difficult to compute the difference in improvement in visual perceptual skills in left and right handed children.

Correlational analysis for the whole group between the variables 'age', 'Perceptual quotient pre-test', 'Perceptual quotient post-test' and 'Perceptual quotient post-pre' was calculated using Pearson correlation coefficient. However, significant correlations were not found between any variable except 'Perceptual quotient pre-test' and 'Perceptual quotient post-test'. Similar results were found in correlation analysis between variables 'age', 'Perceptual quotient pre-test', 'Perceptual quotient post-test' and 'Perceptual quotient post-pre' in perceptuo-motor group, motor-free group, age group 5.0-9.0 years and age group 9.0-11.6 years.

The results suggest that the deficits in Perceptual Quotient (PQ) are not related to age i.e. any age group may have deficits in performance skills to any degree. Also, correlation was not significant between 'age' and 'perceptual quotient post-pre', implying that improvement in perceptual quotient has no relationship with age. That means that improvement in PQ can be expected to varying degrees in all ages of the chosen sample. (i.e., 5-11.6) and the intervention protocol is effective for all age groups (as suggested by the improvement seen in the PQ of MVPT-R for the whole sample).

A significant correlation was found between 'Perceptual quotient pre-test' and 'Perceptual quotient post-test'. This implies that the protocol is effective for children scoring at the lower end of the spectrum and near to normal cut off of 85 in the MVPT–R.

Additional findings: As per MVPT–R, normal cut-off is perceptual quotient of 85. In the pre-test assessment, all 30 children had Perceptual quotient <85, and out of these, 16 children had perceptual quotient <60, which is significantly low than the normal cut-off. In the post-test assessment, although all children showed improved visual perceptual skills, 15 children still had perceptual quotient <85. These 15 children were those whose 'PQ pre-test' scores were on the lower end of the spectrum of scores for the whole sample. Since little evidence is available, to comment about the duration of intervention protocols and their relationship with the levels of improvements seen in the visual perceptual skills; it can only be assumed that with longer duration intervention protocol these 15 children might have achieved better scores.

Conclusion

It was concluded that the prevalence of visual perceptual deficits is significant in typically developing children and no significant difference exists in visual perceptual deficits in males and females. However, right handed children performed significantly better than the left handed children. Also, motor and motor-free visual perceptual trainings bring about similar improvements in visual perceptual skills. There was no significant relationship between 'age' and 'perceptual quotient'.

Limitations

The small sample size limits the generalizability of results. A small percentage of left handed children were there in phase 2 of the study, because of which comparison between improvements in visual perceptual skills in left and right handed children was not possible. Normative information of MVPT-R was not available for Indian population. Therefore, standardized data from MVPT-R had been used for the interpretation of scores. As Minimal Clinically Important Difference (MCID) is not established for MVPT-R, it could not be said whether the improvement was clinically significant or not.

Appendix – A

Intervention protocol	
Motor-Free	**Motor**
DAY 1 **Figure ground visual perception**	
1. Chart 1-50	1. Beads (pick similar beads from an assortment of beads of different colour but same shape) (assortment = 4 colours)
2. Worksheet A	2. Pick one shaped pulses from an assortment of beans, rice and pulses.
Form constancy	
1. Chart 1-50 2. Worksheet B	1. Drawing simple shapes 2. Foam painting
DAY 2 **Visual discrimination**	
1. Chart 1-50	1. colour and cross activity (colour one particular letter and cross another particular letter from a given table of letters)
2. what's missing (from 2 picture cards, compare and find any one missing item from one picture to another)	2. draw missing item (from 2 given picture cards, compare and draw any one missing item in second card)
Spatial relationship	
1. Chart 1-50 2. worksheet C	1. jig-saw puzzle (8 piece) 2. simple crosswords using directionality of "across" and "downwards"

Future research

Since, literature says that improvement in visual perceptual skills could be brought about by protocols of duration as less as 10 hours, shorter duration intervention protocols maybe experimented upon in future studies. In a larger sample size, study could be done to standardize the intervention protocol used in the study.

References

1. Kramer P, Hinojosa J (1993) Frames of reference for paediatric occupational therapy. Williams and Wilkins.
2. Zaba J (1984) Visual perception versus Visual function. Journal of Learning Disabilities: 4: 182-185.

3. Solan HA, Ciner EB (1989) Visual perception and learning: issues and answers. Journal of the American Optometric Association 4: 457-460.
4. Case-Smith J, Allen AS, Pratt PN (1996) Occupational therapy for children. 3rd Mosby-Year Book.
5. Leonard P, Foxcroft C, Kroukamp T (1988) Are visual-perceptual and visual-motor skills separate abilities. Percept-Motor Skills 67: 423-426.
6. Doreen K (1969) Spatial localization in left and right visual fields. Canadian journal of psychology 26: 445-448.
7. Burtner PA, McMain MP, Crowe TK (2002) Survery of occupational therapy practitioners in south-western schools: Assessments used and preparation of students for school-based practice. Physical and Occupational Therapy in Pediatrics 22: 25-39.
8. Kang SH, Kim DK, Seo KM, Choi KN, Yoo JY, et al. (2009) A computerized visual perception rehabilitation programme with interactive computer interface using motion tracking technology-a randomized controlled, single-blinded, pilot clinical trial study. Clinical Rehabilitation 26: 434-444.
9. Burtner PA, Qualls C, Ortega SG, Morris CG, Scott K (2002) Test-retest reliability of the motor-free visual perception test revised (MVPT-R) in children with and without learning disabilities. Physical and Occupational Therapy in Pediatrics 4: 23-36.
10. Auld M, Boyd R, Moseley GL, Johnston L (2011) Seeing the gaps: a systematic review of visual perception tools for children with hemiplegia. Disability and Rehabilitation 33: 1854-1865.
11. Colarusso RP, Hammill DD (1996) Motor-free visual perception test-revised (MVPT-R) Manual.
12. Marcia CL, Peterson AC (1985) Emergence and characterization of sex differences in spatial ability: a meta-analysis. Child Development 56: 1479-1498.
13. Tartaglia EM, Bamert L, Mast FW, Herzog MH (2009) Human perceptual learning by mental imagery. Current Biology 19: 2081-2085.
14. Grigorieva L, Bernadskaya M, Svechnikov V (1997) Visual perceptual training of children with multiple disabilities in Russia. ICEVI's Xth World Conference. Sao paulo, Brazil.