

Review Article

Visualizing Success: A Systematic Review on Visual Perceptual Interventions across Paediatric Spectrum

Zahabiyah Doctor*, Dr. S.K. Meena, Dr. Neha Jain & Marziyah Doctor
Mahatma Gandhi Occupational Therapy College, MGUMST

Abstract

This study aims to review existing literature to analyse the effectiveness of visual perceptual interventions in improving visual perceptual and concomitant difficulties across various paediatric conditions. Databases including PubMed, Google Scholar, ResearchGate and others were extensively searched for studies published since 2012 till date. Included studies investigated the prevalence of visual perceptual difficulties and their relationship with other difficulties or conditions as well as the effectiveness of visual perceptual training in improving visual perceptual and concomitant difficulties. Quality assessment and data extractions were done which adhered to predetermined criteria. Overall, 17 studies which met the inclusion criteria were examined, where various interventions including multimedia group, multimedia individual, paper-based, motor-based, motor-free, teacher-assisted, and Frostig's visual perceptual training program were provided across a multitude of paediatric conditions. Findings suggest all programs were effective, though in varying degrees, in improving visual perceptual and associated difficulties.

Conclusion: Manifesting in a variety of ways and causing a multitude of associated difficulties, visual perceptual deficits result in far reaching negative implications across various aspects of a child's development, performance areas and contexts. This review provides comprehensive evidence supporting the effectiveness of different visual perception training programs in improving visual perceptual and concomitant difficulties across various paediatric conditions and supports the need to study the relative effectiveness of all the different approaches in comparison to each

other. Findings highlight the importance of implementing diverse intervention approaches tailored to specific paediatric conditions and develop a standardized protocol for different aged children suffering from specific disorders.

Keywords: Visual perception, Visual perceptual training, Children, Occupational therapy

***Correspondence**

Ms. Zahabiyah Doctor
zahabdoctor@gmail.com
Mahatma Gandhi Occupational Therapy College, MGUMST, Jaipur, India

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Introduction

Visual perception plays a crucial role in our everyday life, influencing not only our ability to navigate the environment but also shaping our social interactions, perceptual-motor skills and cognitive processes ^{[1][2]}. The intricate interplay between the eyes and the brain helps us to make sense of, organize, interpret and comprehend an immensely complicated world, full of a potentially bewildering jumble of overlapping objects, textures, colours, contrasts, shapes and contours, constantly undergoing change ^[3].

Defined as the composite process responsible for the reception and cognition of visual stimuli, visual perception encompasses the skills of visual attention, visual memory, visual discrimination, form constancy, visual closure, figure-ground recognition, position in space, visual spatial orientation, depth perception and topographic orientation ^[4]. It is a

complex and systematic neurophysiological process that relies on relevant brain development ^[1].

Some components of visual perception are present since birth; these and other capabilities continue to fully develop until adolescence, with all visual perceptual components rapidly developing between 3 ½ and 7 years of age ^[1] ^[4]. This marks a crucial window of time for guiding intervention.

A child experiencing visual perceptual difficulties may struggle to recognize familiar objects if partially obscured; encounter difficulties sorting and organizing personal belongings; face challenges in understanding directional language, experience issues with cutting, colouring, construction toys, solving puzzles; tying shoelaces, matching colours etc. ^[5] They might also demonstrate poor visual memory, frequently coupled with poor recognition of objects, images, and symbols, as well as a poor memory of places and occurrences ^[6]. A deficit in visual-spatial relationships could increase the chances of letter, number, or word reversals. Children may have problems in correct letter formation, spelling, grammar mechanics, punctuation and capitalization, and formulation of a sequential flow of ideas necessary for written communication ^[5]. The application of these skills significantly affects a child's participation and his/her role in the community as a child, student and friend ^[2].

The reviewed literature indicates that children across various conditions such as ADHD, ASD, CP, DCD, low-vision, hearing impairment, handwriting difficulties, learning disorders, developmental delay, to name a few, suffer from visual perceptual difficulties. Thus, it becomes necessary to understand the real-world implications of visual perception

difficulties; exploring their impact on various aspects of a child's overall development and life.

Significance of study

The significance of this study lies in the fact that innumerable children suffering from a plethora of conditions experience visual perceptual difficulties. Moreover, a staggering 62.42% of typically developing, school going children also experience the same ^[7]. A multitude of studies conducted throughout the years have highlighted the fact that various difficulties, for example, difficulties in visual-motor integration, coordination, motor skills, working memory, reading and spelling ability, handwriting, mathematical communication skills etc. are more often than not are a result of or mask the underlying, causal difficulty of visual perception. All these have a cumulative effect and negatively impact a child's ADL and academic performance, social life, and overall quality of life ^[1].

This study aims to provide a comprehensive and evidence-based understanding of the relationship of visual perceptual skills to multiple, other skills as well as the relative effectiveness of different visual perceptual intervention approaches in addressing visual perceptual as well as concomitant difficulties across various paediatric conditions. It has the potential to assist educators, parents, and practitioners by amalgamating current research, pinpointing effective strategies, and providing insights into the most influential methods for enhancing children's visual perceptual and associated skills. Doing so, will enhance patient outcomes, ensuring that children attain independence and elevate their quality of life.

This study has the capability to enhance the quality of interventions aimed at combating visual perceptual and concomitant difficulties in children. It is poised to become a valuable asset for future studies, aiding researchers in pinpointing deficiencies in existing literature and highlighting areas requiring additional exploration. Furthermore, it will assist upcoming practitioners in devising innovative interventions grounded in evidence.

Research Methodology

Studies were included based on the objectives of the current review. Inclusion and exclusion criteria were prepared and based on those criteria; various databases were used in the selection of the studies. The studies collected for the review were checked for clarity and content and then used.

Criteria for the sample collection

Two criteria i.e., inclusion and exclusion criteria were used for the collection of samples.

Inclusion criteria

- **Participants:** Children with visual perceptual difficulties within a defined age range (3-17 years)
- **Publication Types:** Peer-reviewed journal articles, conference papers, full text papers.
- **Study Design:** Randomized controlled trials (RCTs), experimental studies, quasi-experimental studies, observational studies, longitudinal and cross-sectional studies.
- **Types of interventions:** Studies utilizing visual perceptual interventions for improving visual perception or associated difficulties.

- **Outcomes and outcome measures:** Studies reporting improvement in visual perception, visual-motor integration, handwriting skills, ADL performance, reading and spelling ability, mathematical communication skills, social skills, working memory, attention, motor skills, coordination and imitation using standardized assessment tools or validated measures.

Exclusion criteria

- **Participants:** Studies involving participants outside the specified age range, with significant loss of vision, with significant comorbidities or medical conditions that would make participation unsafe, with an inability to understand or communicate verbally or follow instructions and commands or with significant cognitive impairment.
- **Publication Types:** Non-peer-reviewed sources, editorials, dissertations and opinion pieces.
- **Study Design:** Case studies and anecdotal reports without a control group for comparison and studies with methodological flaws or insufficient statistical power, meta-analyses.
- **Intervention:** Studies evaluating interventions other than visual perceptual interventions and those with insufficient detail on the intervention methodology.
- **Outcomes:** Studies lacking relevant outcome measures or those focusing solely on behavioural outcomes without a significant emphasis on visual perceptual abilities.
- **Publication date:** Studies published more than 12 years prior.

Electronic database searching

The databases searched include PubMed, Google Scholar, ResearchGate, ERIC and Science Direct.

Data extraction and quality assessment

The articles were selected on the basis of PRISMA flow diagram. Eligibility criteria were assessed for the extracted data. Those studies not meeting the criteria were excluded. Included studies were evaluated based on their relevance, appropriateness, clarity and methodology. Selected articles were assessed by two independent reviewers (2nd and 3rd author). The data extracted included participants, year of publication, study method, type of intervention and outcome

Analysis

Steps in the analysis: -

Step 1: Obtained data was tabulated and classified according to author/ year of publication, research design, number of participants & sample characteristics, intervention and results.

Step 2: Identifying the findings of the studies- The studies were identified via their setting, method, sample size, type of intervention and components of the intervention.

Step 3: Categorizing the findings- Findings were categorized under the headings of the effect of enhanced occupational therapy intervention on the study "Visualizing Success: A Systematic Review on Visual Perceptual Interventions across Paediatric Spectrum."

Results and Discussion

The reviewed studies included 50 potentially relevant articles out of which 27 were excluded as they did not meet the inclusion and exclusion criteria and 6 as they did not mention the category of the participants. Seventeen studies were eventually included, encompassing a diverse range of paediatric conditions.

Examined interventions including multimedia group, multimedia individual, paper-based, motor-based, motor-free, teacher-assisted, and Frostig's visual perceptual training program were used for treatment. It was found that all programs were effective, though in varying degrees, in treating visual perceptual and associated difficulties such as visual-motor integration, handwriting skills, ADL performance, reading and spelling ability, mathematical communication skills, social skills, working memory, attention, motor skills, coordination and imitation.

Characteristics of the articles

Out of 17 studies included in the review, all of them were qualitative studies with majority of them being conducted in the hospital setting. These studies were published between the years 2012 to 2024.

S. No.	Author/ Year of Publication	Research Design	No. of Participants & Sample Characteristics	Intervention/ Study Procedure	Results
1.	Saida Aladwan, Worud Awamleh, <i>et. al</i> (2023)	Cross-sectional, correlational study.	90 primary-stage students diagnosed with mathematical	Data collection done via validated, study researcher prepared Visual Perception Skills test and the written	Statistically significant positive association between VP skills and written mathematical communication skills.

			learning disabilities.	mathematical communication skills test. Analysis done via SPSS to determine association.	
2.	Supawadee C. Lee (2022)	Descriptive, correlational study.	65 children in grades 1 to 3.	DTVP-2 and ETCH administered by the research assistants. Analysis done to determine relationship between the individual sub-components of visual perception and overall scores achieved by ETCH for letter, word and numeral legibility and to identify best predictors of handwriting.	The best predictors for word legibility included spatial relations and figure-ground perception, for letter legibility was visual closure and for number legibility was position in space.
3.	Sakineh Soltani Kouhbanani, Somayeh Zarenezhad (2021)	Pre-test, post-test quasi-experimental study.	40 children with DCD aged 7-9 years. EG: 20; CG: 20)	EG: 16, 30min sessions of perceptual skills reconstruction program. (2/week) CG: routine school programs but received no skills training.	Compared to CG, statistically significant effect on the growth of perceptual-motor macro performance, perceptual-motor equilibrium performance and fine motor perceptual function.
4.	I-Jou Chi, Ling-Yi Lin (2020)	Cross sectional descriptive study.	92 preschool children aged 4-7 years- 46 with ASD (G1) & 46	AMPS and PEDI-C used to measure the self-care performance. TVPS-3 and DTVP-3	G1 had significantly lower scores on the performance of self-care and visual

			typically developing children. (G2)	were used to evaluate visual perception. Data analysis done to analyse the differences in self-care and visual perception between the two groups and to examine the relationship between self-care and visual perception.	perception compared with G2. In G1, children with greater self-care performance demonstrated better VP skills.
5.	Ramona Cardillo, <i>et. al</i> (2020)	Case-control study; community population study.	150 children aged 8-18.5 years. EG1: 40 ASD children; EG2: 21 children with NLD; EG3: 29 ADHD children; CG: 60 typically developing children.	Participants tested individually during two, 40min sessions using four tasks adapted from the Block Design Task (BDT) which were devised to assess four different visuospatial processing domains: visuospatial processing speed, visuo-perceptual abilities, visuo-constructive abilities and visuospatial working memory. For each task, stimuli had 3 different levels of Perceptual Cohesiveness. (PC)	Significant effects found in Group, Condition, and Level of PC, indicating accuracy and response time differences. NLD and ADHD groups showed lower accuracy, with NLD performing worse than ADHD. The local-global processing index had limited accuracy, except in the BDT task, where it moderately discriminated NLD from ASD and TD, and ASD from ADHD in accuracy and response times.

6.	Mehta, Pooja; Nandgaonkar, Hemant (2019)	Interventional study.	10 children with handwriting difficulties aged 6-10 years.	24, 45min individualized, structured VP training sessions (2/week) which included preparatory activities, tabletop activities and paper-pencil tasks by first author with a customized weekly home program given to each child following each session.	Statistically highly significant improvement in mean scores of LCT; significant differences in the mean scaled scores all subtests of TVPS-3 and overall performance with maximum improvement in visual discrimination; significant differences in all scores of ETCH-M except in far-point copying speed.
7.	Ling-Yi Lin (2019)	Cross sectional study.	72 preschool children aged 4- 6 years.	PPVT-R, the TVPS-3, and the three fine motor subtests of the BOT-2 administered by registered OT in EG1 (tablet using) and EG2 (non-tablet using).	Both groups showed typical VP and fine motor performance. EG1- significantly lower scores for all VP skills except sequential memory and visual closure than EG2. EG2- significantly higher scores in fine motor precision, fine motor integration, and manual dexterity than EG1. Different patterns of correlations between VP and fine motor skills were observed in two groups with

					children who spent more time using tablets having lower scores on fine motor precision, visual discrimination, and spatial relationships.
8.	Elahe Bapirzadeh, <i>et. al</i> (2017)	Pre-test, post-test group quasi-experimental study.	24 third grade elementary school students with learning disabilities. (EG: 12; CG: 12)	EG: 10, 30-45min individual sessions. Active memory strengthening strategies taught by Sina Research Institute's "active memory strengthening" software and Frostig test strategies used to strengthen visual perception. CG: received no training.	Statistically significant difference between EG and CG in terms of average spelling scores post intervention.
9.	Harshita Misra, Ruby Aikat (2016)	Interventional study.	School going children- Phase 1: 173, Phase 2: 30 with MVPT-R score less than 85.	Phase 1: MVPT-R results recorded and statistical analysis done to find out the prevalence of VP deficits and to compare the prevalence between genders and handedness.	Phase 1: Statistically significant point prevalence found -0.62 with right-handed children having significantly better performance on MVPT-R than left-handed ones. Phase 2: Statistically significant improvement in

				Phase 2: 12, 30min sessions (3/week) with EG1 receiving visual percepto-motor training and EG2 receiving motor free VP training.	VP skills in both groups (EG1= EG2)
10.	Mahdi Garmabi, <i>et.al</i> (2016)	Pre-test, post-test quasi-experimental study.	36 boy students with hearing impairment aged 7-10 years. (EG: 18; CG: 18)	EG: 10, 45min (1/week) visual perception intervention sessions compiled based on Frostig Developmental Program of Visual Perception CG: no training given.	Statistically significant improvement in short-term visual memory in EG compared to CG.
11.	Ahmed Mahmmoud, <i>et. al</i> (2016)	Pre-test, post-test quasi-experimental study.	36 mild intellectually disabled native Arabic children in Egypt aged 9-11.5 years.	EG1 (teacher-assisted, paper-based VP training): 50, 40min group sessions (5/week). EG2 (BFT-computerized VP training): 50, 40min individual sessions (5/week). CG: training as usual.	Statistically significant improvement in VP, reading skills and IQ in EG1 and EG2. (Differences not statistically significant)
12.	MiLim Cho, <i>et. al</i> (2015)	Interventional study.	56, 4-7 years old children diagnosed with CP	24, 30min (3/week) visual perceptual training program sessions- 48 tasks based on Frostig	Statistically significant improvement in VMI and WeeFIM raw scores.

				Developmental Program of Visual Perception.	
13.	Leila Safaei, <i>et. al</i> (2014)	Pre-test, post-test quasi-experimental study.	30, 2 nd grade elementary school students with learning disabilities.	EG: 15, 45min (2/ week) visual perceptual skills training sessions using picture cards and education. Games and learning materials used included puzzles, memory cards, maze, rings and rods, etc. CG: no intervention	Statistically significant improvement in basic reading skills and reduction in common visual errors in EG.
14.	Natalia Fusco, <i>et. al</i> (2015)	Comparative study.	20, 3-5 th grade elementary students; 10 (developmental dyslexia), 10 (good academic performance).	12, 50min sessions comprised of 8 exercises, 1 of visual-motor coordination and 7 of VP. (2/week)	Statistically significant improvement in VP and handwriting skills (G1> G2 in handwriting)
15.	Jayachandran Vetrayan, <i>et. al</i> (2015).	Correlational study.	20, 4-9.5 years old children with autism.	All the participants tested DTVP-2, MIS and UIA according to standard procedure. Based on the teacher report SFA was conducted at the participant school setting. Data analysed	School function of autistic children have a significant relationship with visual perception and imitation performance especially the Motor-reduced Visual Perception sub-test, unstructured gesture and object imitation.

				via SPSS-18 to determine relationship.	
16.	Yi-Nan Chen, <i>et. al</i> (2013).		64, preschool children with developmental delays aged 4–6 years.	EG1 (multimedia VP group training), EG2 (multimedia VP individual training), EG3 (paper-based individual VP training) and CG. OT sessions given to all groups (1/week) with additional VP training sessions (1/week) given to EG-1,2,3. Teaching materials prepared via Microsoft PowerPoint and administered through screen to EG-1,2 and by printing on A4 paper to EG3.	Statistically significant improvements in VP skills. (EG1> EG2 > EG3). EG3 improvements disregarded as considered not overcoming developmental effects.

17.	Songül Atasavun Uysal, Tülin Düger (2012)		40, 7-14 years old children with low-vision.	24, 45min (2/week) VP training programmes based on Warren's exercises given. In EG- 1: aided paper and pen; in EG-2: with computer.	Statistically significant improvement in ADL performance and social skills in both groups. (EG1 = EG2).
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*EG=experimental group; CG=control group; VP=visual perception; NLD=Nonverbal learning disability; TD=typically developing; ETCH=Evaluation Tool of Children's Handwriting; PEDI-C=Paediatric Evaluation of Disability, Chinese Version; PPVT-R=Peabody Picture Vocabulary Test-Revised; BOT-2=Bruininks-Oseretsky Test of Motor Proficiency, Second Edition; BFT=Brain Fitness Training; MIS=Motor Imitation Assessment; UIA=Unstructured Motor Imitation Assessment; SFA=School Function Assessment.

Conclusion

In summation, the existing body of literature underscores the widespread nature of visual perceptual deficits across a multitude of paediatric conditions as well as in typically developing children. A child's cognitive capacity is fundamentally shaped by visual perception in the sense that it orientates and regulates a child's behaviour. Manifesting in a variety of ways and causing a multitude of associated difficulties, deficits thus result in far reaching negative implications across various aspects of a child's development, performance areas and contexts.

The individual visual-perceptual constructs are interdependent with improvements occurring through experience, stimulation and exercise. Thus, designed interventions should incorporate all three elements in their approach in order to maximise their effectiveness.

This review provides comprehensive evidence supporting the effectiveness of different visual perception training programs in improving visual perceptual and concomitant

difficulties across various paediatric conditions. The findings emphasize the importance of implementing diverse visual perception intervention approaches alone or in different combinations integrating the strengths of each approach, tailored to specific paediatric conditions.

It supports the need to study the relative effectiveness of all the different approaches in comparison to each other, and develop a standardized protocol for different aged children suffering from specific disorders. These findings, thus, have implications for clinicians and researchers involved in developing targeted interventions to enhance ADL performance, academic achievement, social life and overall quality of life in these children.

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