REVIEW ARTICLE

# Exploring Visual Perception Among Children With Developmental Disability: A Scoping Review

Khairul Anam Md Yakup[1,2], Lilyana Davina David[1,3], Norzie Azlaili Pudzi[1,4], Anis Hidayu Abd Shukor[1,5], Mohamad Qayum Mohamad Sabri[1] ,Akehsan Dahlan[1]

[1] Centre of Occupational Therapy, Faculty of Health Sciences, Universiti Teknologi MARA (UiTM), UiTM Kampus Puncak Alam, 42300 Bandar Puncak Alam, Selangor, Malaysia
[2] Klinik Kesihatan Tandek, Peti Surat 421, 89108 Kota Marudu, Sabah, Malaysia
[3] Hospital Selayang, Lebuhraya Selayang-Kepong, 68100 Batu Caves, Selangor, Malaysia
[4] Hospital Putrajaya, Jalan P9, Present 7, 62250 W.P. Putrajaya, Malaysia
[5] Hospital Kuala Lumpur, Jalan Pahang, 50586 Kuala Lumpur, Malaysia

## ABSTRACT

This scoping review is guided by its research question to explore an overview of the domains assessed and the associated variables of occupational therapy visual perception (VP) assessment among children with developmental disabilities (DD). Articles that provided relevant information on both VP assessment and children with DD were included in this review. Pertinent studies that were published from the year 2000 to 2021 were included. Twenty articles met inclusion criteria. The findings highlighted eight domains of VP assessed in children with DD: (i) visual memory; (ii) sequential memory; (iii) form constancy; (iv) visual closure; (v) figure-ground; (vi) visual discrimination; (vii) spatial relation; and (viii) position in space. VP assessment explored the visual perception skills of children with DD as individuals and as students. This scoping review mapped the utilization of VP assessment by an occupational therapist to guide clinicians when exploring suitable VP assessment for children with DD.
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**Corresponding Author:**
Akehsan Dahlan, PhD
Email: akehsan@uitm.edu.my
Tel: +603-32584380

## INTRODUCTION

Visual perception (VP) was defined as the ability to receive, recognize, interpret, and elaborate on visual stimuli elicited by things and events (1). Its entirety is responsible for the reception (sensory functions) and cognition (specific mental functions) of visual stimuli (2). Sensory function is the process of obtaining and organizing information from the environment. In contrast, specific mental functions allow for organizing, structuring, and interpreting visual inputs, giving meaning to what is seen (2). When the two processes work together, individuals can comprehend what they see, and both functions are essential for functional vision, which contributes more significant help in performing daily living activities. Brown (3) suggested that VP consisted of two interconnected processes: motor-reduced visual perception (purer VP) and motor-enhanced visual perception (also known as visual-motor integration).

VP ability is one of the fundamental skills required for children's everyday activities (4,5). Education, activities of daily living (ADL), play, leisure, and social participation may all be affected if these skills are disrupted (6). A typically developing child, for example, may struggle with activities of daily living such as using a mirror to comb hair, putting toothpaste to the brush, wearing clothes, and tying shoes (7).

Prior studies have shown that VP skills in children with developmental disabilities (DD) are significantly impaired compared to typically developing children (8–12). According to Olusanya et al. (13), occupational limitations produced by abnormalities of the growing nervous system throughout infancy and childhood are known as developmental disabilities. These limitations manifest themselves as developmental milestone delays or dysfunction in multiple domains, such as cognition, motor skills, vision, hearing, speech, and behavior, throughout infancy and childhood (13). Sensory impairments (hearing and vision loss), epilepsy or seizures, cerebral palsy (CP), attention deficit hyperactivity disorder (ADHD), autism spectrum disorder (ASD), intellectual disability (ID), or other learning disorders (LD) are common in these children (13).

Current studies by Chi and Lin (9) discovered a relationship between self-care performance and VP skills among children with ASD. In addition, in children with CP, the VP was related to mathematics ability (10) and ADL performance (14). In comparison, Jung et al. (15) found that sensory processing may be a hallmark of children with ADHD who have VP problems. Other than that, there were also studies indicating that children with Down's syndrome (DS) (12), Developmental Coordination Disorder (DCD) (16), and unique learning disability (SLD) (17) perform significantly worse on VP abilities.

Occupational therapists recognize their unique skills in VP evaluation and intervention with children (18). Based on research and philosophy such as family-centered care and the World Health Organization's International Classification of Functioning, Disability, and Health (ICF; 19), occupational therapists' approaches have grown and altered (20). These frameworks have led many occupational therapists to shift away from impairment-based interventions aimed at correcting the child's deficits at the body structure and function level, and instead focus on improving functional activity performance and participation, as well as partnering with parents to deliver therapy embedded in daily life (21). As a result, occupational therapists must use solid clinical reasoning to link the child's occupational performance deficits to the fundamental factors associated with VP.

Since numerous studies suggest that children with DD have VP impairment that can affect their daily living skills, school performance, play, leisure, and social participation (4,7,22). However, there is inconsistency in selecting and administering VP evaluation tools for this population. Recently, only one systematic review exists focusing on VP tools for children with hemiplegia (23). Schneck (2) also emphasized that visual perception is one of the least understood areas of evaluation and treatment. Hence, this scoping review aimed to provide an overview of the available assessment used to address the VP skills of children with DD. In addition, it mapped the utilization of the VP assessment in children with DD.

## METHOD

This scoping review was reported by using the (PRISMA-SCR) (24) and guided by a framework as recommended by Arksey and O'Malley (25) that comprises five stages: (1) Identifying the research question, (2) Identifying the relevant studies, (3) Study selection, (4) Charting the data, and (5) Collating, summarizing and reporting the result as shown in Figure 1

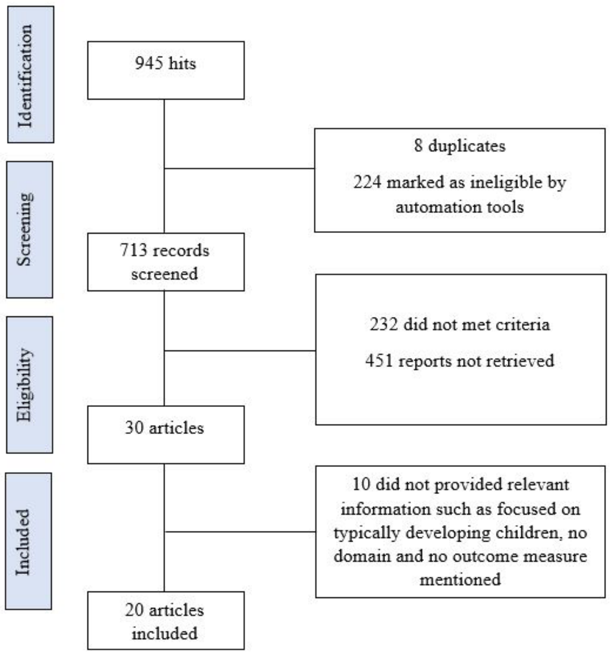


**Figure 1: PRISMA flow diagram for the scoping**

### Identifying the Research Questions
The research question guiding this scoping review is, "What were the domains assessed and the associated variables with VP assessments?"

### Identifying Relevant Studies
Relevant studies were identified by searching through the following database, including Web of Science, Medline, Scopus, and ProQuest, using the keywords visual perception, assessment, occupational therapy, and developmental disability. The articles included in the review were the title, keywords, or abstract of the English-language source to provide relevant information on both VP and DD. All peer-reviewed articles, non-peer-reviewed sources, and thesis were screened for potential inclusion. If the source did not include DD by name, it had to include reference to the diagnoses associated with DD (e.g., cerebral palsy, Down syndrome, dyslexia, autism spectrum disorder, learning disability, and attention deficit hyperactivity disorder). Sources that addressed only the VP for the normal population of children were excluded. Four reviewers (AH, KA, LD, NA) independently reviewed 945 titles and abstracts. The process was elucidated in Fig.1.

### Selection of Studies
Records were included when they were available in English or translated to English. Evaluation tools that assessed VP in DD children between 2000 until 2021 were included. Participants in the study had to present with any DD at the start of the study. Studies on the VP tools done on the non-developmental disabled population were excluded. Meta-analysis was also

considered as long as these studies adhered to the inclusion criteria.

### Charting the Data

The charting of data was made from all captured information relating to the author(s) and year of publication, location of the study, study aims and purpose, study population and sample size, study methodology, domain, and the associated variables with VP assessments that related to the scoping review question. An analytic approach was used during data charting to identify and extract the domain and the associated variables with VP assessments (26,27).

### Collating, Summarizing and Reporting the Results

The content analysis focused on the domain and the associated variables with VP assessments assessed within the DD population. Four reviewers (AH, KA, LD, NA) independently completed the data extraction, with KA ensuring accuracy and consistency while resolving conflicts across reviewers. AH, KA, LD, and NA conducted the content analysis and refinement.

**Table I: Summary of the articles.**

| Author(s) | Study design | Population of the studies/ sample size/ Country | Visual Perception Instruments | Summary of findings | Contribution in this study |
|---|---|---|---|---|---|
| Auld et al. (2011) | Systematic review | Cerebral palsy-hemiplegia<br>Australia | 1. Test of Visual Perceptual Skills (TVPS)<br>2.Motor-Free Visual Perceptual Test (MVPT)<br>3. Developmental Test of Visual Perception (DTVP). | DTVP and MVPT demonstrate the strongest clinimetric properties and recommended for clinical practice. | 1 |
| Bellocchi et al. (2017) | Longitudinal study | Dyslexics (n=20)<br>Typical<br>developing child (n=40)<br>France | Developmental Test of Visual Perception version 2 (DTVP-2) | Dyslexics showed lower motor-reduced VP and visual-motor integration skills which were associated in learning to read. | 1, 3 |
| Berelowitz & Franzsen (2021) | Cross sectional study | Cerebral palsy (n=80)<br>South Africa | The Test of Visual Perceptual Skills 3rd ed. (TVPS-3) | All the subtypes of CP were found to present with VP impairments. No significant differences were found for VP based on GMFCS levels. | 1, 2 |
| Bischof et al. (2012) | Cross sectional study | Spastic diplegia (n=40)<br>South Africa | Beery-Buktenica Developmental Test of Visual Motor Integration (VMI) | There were significant correlations between VIS and VMI scores and school grade appropriateness in children with spastic diplegia. | 2, 3 |
| Chen et al. (2013) | Experimental study | Developmental delays (n=64)<br>Taiwan | The Test of Visual Perception Skills, third edition (TVPS-3) | The multimedia visual perceptual group training program was more effective for improving VP than was multimedia visual perceptual individual training program. | 1 |
| Chi & Lin (2021) | Cross sectional study | Autism Spectrum Disorder (n=66)<br>Typically developing child (n=66),<br>Taiwan | 1.The Test of Visual Perceptual Skills-Third Edition (TVPS-3)<br>2.The Developmental Test of Visual Perception-Third Edition (DTVP-3) | Positive correlations were found between self-care performance and VP ability in children with ASD. | 1, 2 |
| Critten et al. (2018) | Cross sectional study | Cerebral palsy (n=32)<br>Typical developing child (n=32).<br>United Kingdom | 1.BPVS-III<br>2.Mathematics Oral test<br>3.British Ability Scales 3rd edition (BAS3) Matrices<br>4.Mathematics written paper,<br>5.Mental Rotation Task<br>6.Working Memory Test Battery (WMTB-C) Block Recall7. TVPS-3 (R) | Receptive vocabulary and VP abilities were the best predictors of mathematical ability in the CP group. | 1, 3 |
| Cuomo (2001) | Cross sectional study | Learning disabilities (n=11)<br>United States | 1.Test of Visual Perceptual Skills—Revised<br>2. Handwriting Checklist. | There were a relationship between TVPS-R and handwriting performance among children with LD. | 1, 3 |

CONTINUE

**Table I: Summary of the articles.(Cont.).**

| Author(s) | Study design | Population of the studies/ sample size/ Country | Visual Perception Instruments | Summary of findings | Contribution in this study |
|---|---|---|---|---|---|
| Desai & Rege (2005) | Cross sectional study | Cerebral palsy (n=10)<br>Typical developing child (n=40),<br>India | 1. The Developmental Test of Visual-Motor Integration<br>(VMI) (Beery, 1997)<br>2. The Modified Scale of Children's Readiness In Printing (SCRIPT) | The findings shows that low VMI scores, his handwriting skills will be affected. | 3 |
| Gьnal et al. (2019) | Cross sectional study | Autism (n=32)<br>Typical developing child (n=30)<br>Turkey | 1.Bruininks Oseretsky Test of Motor Proficiency (BOTMP)<br>2.The Lowenstein Occupational Therapy Cognitive Assessment (LOTCA) | There was a strong relationship between perception, VP, and self-care and social function according to Paediatric Evaluation of Disability Inventory (PEDI) of children with autism. However, no relationship of VP measured by LOTCA and mobility as determined by PEDI. | 2 |
| James et al. (2015 | Cross sectional study | Cerebral palsy (n=101)<br>Australia | 1. Assessment of Motor and Process Skills (AMPS),<br>2. Jebsen–Taylor Test of Hand Function (JTTHF)<br>3. Assisting Hand Assessment (AHA)<br>4. (4) Test of Visual Perceptual Skills, 3rd edition (TVPS-3) | Process skills of ADL are related to VP ability and dominant upper limb unimanual capacity. | 2 |
| Jung et al. (2014) | Cross sectional study | ADHD (n=47),<br>Korea | 1. Korean Developmental Test of Visual Perception-2<br>2. Short Sensory Profile<br>3. Kiddie-Schedule for Affective Disorders and Schizophrenia-Present and Lifetime Version-Korean Version | The results reflect that decreased sensory processing may be a hallmark of children with ADHD who have VP problems. | 1, 2 |
| Oliver (2013) | Cross sectional study | Autism Spectrum Disorder (n=22)<br>Typically developing child (n=23)<br>United State | 1. The Bender-Gestalt Test-Second Edition (BG II)<br>2. The Beery-Buktenica Developmental Test of Visual-Motor Integration, 5th Edition (VMI-V)<br>3. The NEPSY Second Edition (NEPSY-II)<br>4. The Test of Visual Perceptual Skills-3 (TVPS-3) | The results indicated VP was the best predictors of reading ability, writing, and math skills among ASD childrens. | 1, 2, 3 |
| Surkar & Writer (2010) | Prospective, parallel design study | Typical developing children (n=30)<br>Children diagnosed with epilepsy (n=30)<br>India | 1.Loewenstein Occupational Therapy Cognitive Assessment Scale (LOTCA) | Visual-spatial perception by using LOTCA instruments is one of the contributory factors for gross motor dysfunction such as balance in children with epilepsy. | 1, 2 |
| Tsai, Lin, Liao, & Hsieh (2009) | Cross sectional study | Cerebral palsy (n=52)<br>Taiwan | 1.Motor-Free Visual Perception Test–Revised (MVPT–R)<br>2.The Test of Visual–Perceptual Skills–Revised (TVPS–R) | The results indicate that the total scales of the MVPT–R and TVPS–R can be used at the individual or group level of children with CP. | 1 |
| Vetrayan et al. (2015) | Cross sectional study | Autism (n=20),<br>Malaysia | Developmental Test of Visual Perception: Second Edition (DTVP-2) | The result revealed that the school function of autistic children has a significant relationship with their VP and imitation performance. | 1, 3 |

CONTINUE

**Table I: Summary of the articles (Cont.).**

| Author(s) | Study design | Population of the studies/ sample size/ Country | Visual Perception Instruments | Summary of findings | Contribution in this study |
|---|---|---|---|---|---|
| Wan et al. (2015) | Cross sectional study | Down syndrome (n=70)<br>Typical developing child (n=70)<br>Intellectual disabilities (n=40)<br>Taiwan | Test of Visual Perceptual Skill-Third Edition (TVPS-3) | Significant between-group differences in TVPS-3 were observed between either DS or ID and TD groups. There was no significant difference on TVPS-3 between DS and ID groups. | 1 |
| Gajre Mona et al. (2015) | Observational prospective study | Specific Learning disability (n=99)<br>India | 1. The test of visual perceptual skills 3rd edition (TVPS-3)<br>2. The developmental test of visual motor integration tests (VMI) | The result shows that VP skills were affected significantly among all SLD categories (dyslexics, dysgraphics, and dyscalculics). | 1 |
| Wuang & Tsai (2017) | Cross sectional study | Williams syndrome<br>(n =38)<br>Taiwan | Test of Visual Perceptual Skill, Third Edition (TVPS-3) | Cognitive level (IQ) is strongly related to all visual perceptual. The correlations between the TVPS-3 scores and the VABS-C and SFA-C subdomains (activity participation measures) are mostly in the moderate range. | 1, 2, 3 |
| Prunty et al. (2016) | Cross sectional study | Developmental Coordination Disorder (n=28)<br>Typical developing children (n=28)<br>Australia | 1. The Beery-Buktenica Developmental Test of Visual-Motor Integration, (VMI)<br>2. Test of Visual Perceptual Skill (TVPS) | There are significant effects on the VMI, as the DCD group had poorer VP skill compared to typically developmental children. No significant correlation between TVPS subtest and any of the handwriting measures. | 1, 3 |

[1]domains of visual perception assessed, [2]visual perception as an individual, [3]visual perception as a student

**Table II: Domains of visual perception assessed and its associated variables.**

| | Visual Cognitive Functions | | | Object Perception | | | Spatial Perception | |
|---|---|---|---|---|---|---|---|---|
| **Domain assessed** | **Visual Memory** | **Sequential Memory** | **Visual Discrimination** | **Form constancy** | **Visual Closure** | **Figure Ground** | **Spatial Relation** | **Position in Space** |
| **Attention Deficit Hyperactivity Disorder (ADHD)** | | (15) | | (15) | | (15) | (15,35) | (15) |
| **Autism Spectrum Disorder (ASD)** | (9) | (9)) | (9,33) | (9,34) | (9,34) | (9,34) | (9,34) | (34) |
| **Cerebral Palsy** | (10,23,31,32) | (10,23,31,32) | (10,23,31,32) | (10,23,31,32) | (10,23,31,32) | (10,23,31,32) | (10,23,31,32) | (23) |
| **Developmental Delay (DD)** | (28) | (28) | (28) | (28) | (28) | (28) | (28) | |
| **Down Syndrome** | (12) | (12) | (12) | (12) | (12) | (12) | (12) | |
| **Dyslexia** | (17) | (17) | (17) | (8,17) | (8,17) | (8,17) | (8,17) | (8) |
| **Dysgraphia** | (17) | (17) | (17) | (17) | (17) | (17) | (17) | |
| **Dyscalculic** | (17) | (17) | (17) | (17) | (17) | (17) | (17) | |
| **Epilepsy** | | | | | | | (35) | |
| **Intellectual Disability** | (12) | (12) | (12) | (12) | (12) | (12) | (12) | |
| **Learning Disability** | (17,29) | (17,29) | (17,29) | (17,29) | (17,29) | (17,29) | (17,29) | |
| **Williams syndrome** | (30) | (30) | (30) | (30) | (30) | (30) | (30) | |
| **Developmental Coordination Disorder** | (16) | (16) | (16) | (16) | (16) | (16) | (16) | |

CONTINUE

**Table II: Domains of visual perception assessed and its associated variables.(cont.)**

| | | Visual Cognitive Functions | | | | | Object Perception | | | | Spatial Perception | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | VP as an individual | | | | | | | VP as a student | | |
| | Sensory Processing | Visual Motor Integration | Gross Motor | Self-Care | Communication | IQ | Mobility | Social Function | Reading Ability | Handwriting Ability | Mathematical Ability | School Function | School Grade |
| | (15) | (33) | (30,31,35) | (9,11,14,30) | (30) | (30) | (11) | (11,30) | (8,33) | (16,29,33,36) | (10,33) | (30,34) | (37) |

## RESULTS

Twenty articles were eligible for this study. The summaries of the selected articles were presented in Table I, and the domains of VP assessed and its associated variables were shown in Table II.

### Overview of the studies

1. Study design

There were fifteen cross-sectional studies, two experimental studies, one systematic review, longitudinal study, and prospective observational study, reviewed respectively.

2. Population and sample size

The highest population and sample size is CP (n=315) followed by LD (n=130), and ASD (n=118).

3. Location and setting

The studies were mostly conducted in Taiwan (n=5) followed by Australia (n=3), and India (n=3). The selected studies ranged from the year 2000 until 2021.

4. Visual perception assessment

Various standardised assessments on VP were utilised: 1) Test of Visual Perceptual Skills (TVPS) (n=12), 2) Beery-Buktenica Developmental Test of Visual-Motor Integration (VMI) (n=5) , 3) Motor-Free Visual Perceptual Test (MVPT) (n=2), 4) The Developmental Test of Visual Perception (DTVP) (n=5), and 5) The Lowenstein Occupational Therapy Cognitive Assessment (LOTCA) (n=2).

5. Main findings

There were three major domains of VP assessed in children with DD: (i) visual cognitive function (visual memory, sequential memory, and visual discrimination), (ii) object perception (form constancy and figure-ground), and (iii) spatial perception (spatial relation and position in space). The associated variables were divided into two groups: (i) VP as individuals (sensory processing, visual-motor integration, gross motor dysfunction, self-care, communication, intelligence quotient, social function, and mobility) and (ii) VP as students (reading ability, handwriting ability, mathematical ability, school function, and school grade).

### Domain of Visual Perception Assessed

*Visual Cognitive Functions (VCF)*

VCF were assessed in children with DD (28), ASD (9), LD (29), DCD (16), WS (30), and CP population (10,23,31,32) respectively. Meanwhile, one study assessed only sequential memory on the ADHD population (15) and another one only assessed visual discrimination in the ASD population (33).

*Studies assessed on Object Perception (OP)*

OP were assessed in children with CP (10,23,31,32), DD (28), ASD (9, 34), LD (29), DCD (16), and WS (30), DS and ID (12), dyslexia, dysgraphia and dyscalculia population (8,17). Only one study was found limited to assessing form constancy and figure-ground in children with ADHD (15).

*Studies assessed on Spatial Perception (SP)*

Spatial Relation were assessed in children's with CP (10,23,31,32), ASD (9,34), ADHD (15,35), dyslexia (8,17), LD (17,29), DD (28), WS (30), DCD (16), epilepsy (35), DS and ID (12), dysgraphia and dyscalculia populations (17). Position in space were assessed in ADHD (15), ASD (34), CP (23), and dyslexia (8) population respectively.

### Visual Perception as an Individual

*Sensory processing*

The results reflect that decreased sensory processing may be a hallmark of children with ADHD who have VP problems and will have difficulties performing tasks such as matching shapes or objects, or tasks containing unfamiliar stimuli or subtle discriminations (15).

*Visual-motor integration performance*

Oliver (33) revealed TVPS-3 as the most significant predictor of visual-motor integration performance in children with ASD.

*Gross motor dysfunction*

Surkar and Writer (35) reported VP is one of the contributory factors for balance in children with epilepsy. Wuang and Tsai (30) study highlighted an association between VP and motor skills component in activity participation measures (VABS-C) in children with WS. Contrarily, Berelowitz and Franzsen (31) found no significant difference between GMFCS levels and TVPS-3 in children with CP.

*Self-care performance*
Chi and Lin (9) recorded correlations between self-care performance and VP ability in children with ASD. Gunal et al. (11) revealed a relationship between VP and self-care of children with ASD. According to James et al. (14), ADL performance is related to visual sequential memory and visual closure abilities among children with CP. Moreover, difficulties in motor skills and visuospatial construction challenged daily living skills of the children with WS (30).

*Communication*
Wuang and Tsai (30) stated all VP subtypes in TVPS-3 correlate with the communication domain in VABS-C among children with WS.

*Intelligence Quotient (IQ)*
Cognitive level (IQ), measured by WISC-III, is strongly related to all VP domains (TVPS-3) among children with WS (30).

*Social functions*
Gunal et al. (11) identified a relationship between VP (LOTCA) and social function (PEDI) of children with ASD. Besides, all VP subtypes in TVPS-3 correlates with the socialisation skills domain in VABS-C of children with WS (30).

*Mobility*
Gunal et al. (11) found no relationship between VP measured by LOTCA and mobility items in PEDI for children with ASD.

**Visual Perception as a Student**
*Reading ability*
Bellocchi et al. (8) found that children with dyslexia have lower motor-reduced VP and visual-motor integration skills than typical readers, which are associated with reading, and point out the DTVP-2 as the best VP assessment to indicate the reading abilities of dyslexics' children. Furthermore, Oliver (33) found that the VP skills were the most significant indicators of reading competency in ASD.

*Handwriting abilities*
Cuomo (29) found that specific VP subtests in TVPS-R significantly affected handwriting performance in children with LD. Desai and Rege (36) and Oliver (33) suggested VMI was the best predictor of reading competency in ASD and CP children. However, Prunty et al. (16) found no significant correlations between the TVPS and any handwriting measures in the DCD group.

*Mathematical ability*
TVPS-3 (R) were the best predictors of mathematical ability in the CP group (10). Besides, Oliver (33) also found that VMI-V can predict math skills in ASD children.

*School function*
Imitations in school functions among children with ASD have a relationship with motor-reduced VP & visual-motor integration in the DTVP-2 (34). Besides investigating the VP functioning in school-aged children with WS, Wuang and Tsai (30) found the correlations between the TVPS-3 and the SFA-C.

*School grade appropriateness*
Bischof, Rothberg, & Ratcliffe (37) found that the school grade appropriateness in children with spastic diplegia can be predicted from VP assessment.

## DISCUSSION

This scoping review aimed to provide an overview of the VP assessment used among children with DD. Our findings indicate a global perspective on the VP assessment used among children with DD. As most of the studies were cross-sectional studies, the information gathered from a cross-sectional study in this review can be used as a springboard for using a more robust design to support the initial findings (38). Other than that, findings also showed assessments being used by the occupational therapist to evaluate VP in children. The Test of Visual Perceptual Skills dominated current literature. It contradicts the earlier assertion that the Developmental Test of Visual Perception Second Edition (DTVP-2) was the most utilised assessment among occupational therapists to measure VP (39).

**Domains of Visual Perception Assessed**
*Attention Deficit Hyperactivity Disorder, Autism Spectrum Disorder, Down Syndrome and Intellectual Disability Population*
Previous literature mentioned that comorbidity with ADHD has been dramatically studied (40), and changes in VP have been commonly described in people with ASD (41). To our knowledge, a study by Wan et al. (12) was the first study to use standardised psychometric testing to assess overall VP functions in DS, as previous research has only focused on the significant deficiency in language ability (42). Meanwhile, Giuliani, Favrod, Grasset, & Schenk (43) mentioned how VP is affected among the ID population. Therefore more research may be required to measure VP in those four populations mentioned (ASD, ADHD, DS, and ID).

*Cerebral Palsy and Epilepsy Population*
According to Ego et al. (44), there was still a scarcity of data on lesion characteristics related to VP. Still, the

severity of brain damage may influence the severity of VP impairment. Besides that, in a study by Surkar and Writer (35), only domain spatial perception (spatial relation) was assessed using LOTCA. A possible reason is that perceptual impairment in epilepsy patients is most likely caused by structural damage to the prefrontal cortex and dorsal stream (45). As a result, assessing the visual perception domain in these two populations is preferable based on the severity and part of the brain affected.

*Williams Syndrome and Developmental Coordination Disorder Population*
The downside of both articles (16,30) is the small sample size. Therefore, having a bigger sample size is suggested to offer a broader range of possible data and forms a better picture for analysis (46).

*Learning Disability (Dyslexia, Dysgraphia, and Dyscalculia)*
The auditory and VP were discovered to impact mathematical abilities substantially (47). In Gajre Mona et al. (17), below average age scores in discriminating, spatial perception, but not visual memories were obtained in dysgraphia, which contradicted a prior study by Dhingra et al. (47). This might have happened because the dysgraphia has more issues with auditory discriminations, along with visual discriminations, figure-ground discriminations, and perceptual scores (47). TVPS and VMI did not measure auditory factors, and therefore more research may be required to assess the relationship between VP and auditory factors in this population.

**Visual Perception as an Individual**
*Sensory processing*
Sensory processing has an impact on VP performance (1,15,48). The central part of the occupational therapy literature on VP comprises contributions from therapists who use sensory integration or cognitive approaches (49). Surprisingly, only one paper was discovered showing decreased sensory processing may be a distinguishing feature of children with DD who have VP difficulties (15). Impaired sensory processing may be a defining feature of ADHD children who have VP issues. According to Vlok et al. (49), this scope indicated other associations between VP and sensory integration might be investigated in children with DD. However, the therapeutic potential of eye movements as warm-up exercises before visual perceptual tasks, task adaptation to improve particular eye movements, and cognitive techniques as fundamental components of visual perceptual programs have not been well investigated.

*Visual motor integration performance*
VP ability was the most significant predictor of visual-motor integration performance in children with autism (33). However, the outcome was less explored in other DD literature. For the last few decades, there has been a continuing dispute in the empirical literature concerning the association between motor-reduced and motor-enhanced VP skills (3). A previous study provides evidence that motor-reduced VP skills and motor-enhanced VMI skills are interdependent systems (3) which is consistent with the occupational therapists VP conception, the Warren model of the hierarchy of VP (50,51), and VP FOR (2,22).

*Gross motor dysfunction*
VP contributes to gross motor dysfunction, such as balance problems (11,30,35). Gunal et al. (11) recorded that the BOMPT determined the lower motor function related to the visuospatial deficit assessed by LOTCA for children with autism. However, Berelowitz and Franzsen (31) discovered no significant difference in GMFCS levels on any composite scores on the TVPS-3 in children with CP. These findings are consistent with Hamid, Mostafa, Saeid, Hojjat Allah, and Akbar (52), who discovered that the severity of gross motor functioning had no direct impact on the VP skills of children with CP.

*Self-care performance*
VP abilities impact self-care performance among children with DD (9,11,14,30). Children with autism have substantial perception issues, which cause disability by affecting self-care (9,11). However, it is reasonable to believe that a limited motor planning process capability could impact the performance of motor integration-related daily living skills (14,30,53,54). The challenges in performing daily living activities such as wearing clothes, personal hygiene, and mobility are exacerbated by the motor challenges of children with motor planning impairment such as children with CP and WS, which are compounded by their difficulty in visuospatial construction (14,30).

*Communication*
VP domain in the TVPS-3 correlates with the communication domain in VABS-C among children with WS (30). However, there is minimal literature that can support these findings. ID, hearing loss, an expressive language impairment, psychosocial deprivation, autism, elective mutism, receptive aphasia, and CP can all cause a delay in speech development (55). Thus, it is unclear how VP could cause communication problems among children with DD.

*Intelligence Quotient (IQ)*
Cognitive level, measured by WISC-III, is strongly related to all VP domains measured by the TVPS-3 among children with WS (30) may have inferred that most people with DD experienced cognitive deficiencies on tasks requiring precise visuospatial perception and memory (1,56).

*Social functions*
There is a strong relationship between VP and social

function among children with autism and WS (11,30). The significance of vision in allowing new-borns to participate in social interactions has long been acknowledged (22). Emotions are communicated chiefly through facial expressions (57). In the joint attention paradigm, a new-born can shift attention from one person to another or an item of common interest, by the end of the first year, also known as the social imitation (D'Entremont, 1997). When identical objects are accessible, toddlers copy a peer's action on an object (22). However, additional research should be done to understand the relation between visual perception function and social function among different conditions of atypical children.

*Mobility*
VP skills influence functional mobility (59). We perceive our surroundings utilising all of our senses simultaneously, resulting in a complex multimodal representation of space. This multimodal representation can be used to move around our surroundings, interact spatially with them, locate things, and estimate their speed and relative location in space. In turn, this representation is also influenced by our bodily sensations (59,60). Even though ASD is linked to abnormal perceptual and sensory symptoms, surprisingly, Gunal et al. (11) found no relationship between VP and mobility in children with autism.

**Visual Perception as a Student**
*Reading ability*
The VP assessment is a suitable tool to explore the relationship between VP and reading (8,33). However, consideration needs to be highlighted by the examiner before exploring these connections. The level of IQ score might as well be the leading cause of children's difficulty in reading and need longer time to read a simple sentence (61). Many neurodevelopmental, psychiatric, and medical disorders co-occur with ID, especially communication disorders, LD, CP, DS, epilepsy, and various genetically transmitted conditions (56). However, no studies were found to explore the relationship between VP abilities and reading skills among children with dysgraphia and dyscalculia.

*Handwriting abilities*
Standardized assessments such as TVPS, TVPS-R, VMI can be used to predict the handwriting ability of children with DD (16,29,33,36). Other causes that influence handwriting problems are motivation, behavior, fine motor skills, gross motor function, coordination, language, reading, and spelling skills (62,63). According to Prunty et al. (16), tests of VP do not appear to be sensitive to or related to handwriting difficulties in children with DCD. More reading regarding this matter needs to be considered in future studies, among other conditions of DD. However, considering that none of the goals listed in either handbook advise utilizing these tests in the context of handwriting, their application in practice is ubiquitous and problematic (64–66).
*Mathematical ability*
Visual short-term memory, visual reasoning, and mental rotation in the TVPS-3 (R) were the best predictors of mathematical ability in the CP group (10). Oliver (33) found that VMI-V can be used to predict math skills in autistic children. However, these findings are still limited for other conditions and should be discovered in further research for atypical and typically developing children.

*School function*
Autism children's low performance on school-related functional activities is linked to VP skills, particularly in the Motor-reduced VP function (34). It is critical to recognize which VP dysfunction among children with DD causes low functional task performance, such as academic and social functions.

*School grade appropriateness*
Bischof et al. (37) discovered a relation between VP and school grade appropriateness among spastic diplegic children. Nevertheless, there is minimal research regarding this correlation. Visual impairments can have a negative impact on school achievement (8,10,16,29,30,33,34,36). Hence, these imply that it could also result in the child's school grade.

After reviewing the findings, the authors found a massive need for more study on occupational therapy assessments for VP in people with various DD. Our results also indicate that less paper explored these issues according to specific types of DD. Thus, careful interpretations are warranted. In addition, it is recommended such studies also should look into a broader range of DD, such as Angelman syndrome, Fragile X syndrome, Fetal Alcohol Syndrome, and others. A suitable sample size, appropriate assessment tools, and more robust methods are also needed to conclude this review better.

Future studies may also explore the association of VP with play as less focus was given on these areas in children with DD. Lynch & Moore (67) suggested that occupational therapy prioritise play among children with DD as it is their core role (68). Play activities need a significant integration and execution of VP and fine motor abilities (69). Therefore, exploring the association of VP with play in children with DD is needed.

## LIMITATIONS

Few databases were scoped, and non-English articles were excluded. Therefore, valuable anonymous data that were not formally or yet published may exist. In addition, this scoping review covered a wide variance of the population with DD. Hence the conclusion made in this study shall be interpreted carefully. Furthermore, because this paper is not intended to review the evidence of psychometric properties (i.e., validity and reliability) and clinical utility of a VP assessment instrument (70), it is unclear whether or not occupational therapists use those available instruments for children with DD is consistent with best practice and evidence.

## CONCLUSION

This scoping review successfully mapped the utilisation of the VP assessment in children with DD. The scoped found three major domains assessed (visual cognitive function, object perception, and spatial perception) and two associated variables (VP as individuals and VP as students) of VP assessments in children with DD. The evidence suggested VP assessment can be conducted to explore the domain assessed and associated variables considering various ranges of DD. Hence, the results of this study can potentially influence the future orientation of the occupational therapy profession, which may guide clinicians when exploring suitable VP assessments for children with a DD.

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