• Clinical Research •

Guidelines for visual cognitive rehabilitation of visual information processing disorders (2025)

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Abstract

● Visual information processing (VIP) is essential for perception and cognition. It enables the brain to acquire and integrate visual stimuli into coherent representations. Visual information processing disorder (VIPD) is characterized by impairments in visuospatial ability, visual analysis, and visuomotor integration. These deficits significantly affect daily activities, learning, and occupational performance. The etiology of these disorders is multifaceted, including developmental anomalies, traumatic brain injuries, ocular diseases, and surgical interventions. This condition involves multiple disciplines (ophthalmology, pediatrics, neurology, and rehabilitation), posing significant challenges for clinical diagnosis, treatment, and rehabilitation. Despite the growing international focus on these disorders, there remain considerable deficiencies in their diagnosis and treatment within China. Clinicians often have limited awareness of VIPD. Standardized diagnostic criteria are lacking, and rehabilitation approaches remain inconsistent. Visual abnormalities are often overlooked in pediatrics and neurology. In contrast, ophthalmology is limited in addressing disorders related to neurological dysfunction. In response to these challenges, this guide has been developed, drawing on the experiences of Europe and America and integrating local research and practice. It provides practical and systematic guidance for the diagnosis and management of VIPD. The objective is to enhance diagnostic and therapeutic capabilities, foster interdisciplinary collaboration, and improve patients' visual function and quality of life.

● **KEYWORDS:** visual information processing disorder; visual cognition; rehabilitation therapy; guidelines

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INTRODUCTION

Visual information processing (VIP) refers to the brain's ability to extract and organize visual information and integrate it with other sensory inputs and higher cognitive functions. It supports learning and social participation. Visual information processing disorder (VIPD) has multiple causes, including developmental abnormalities, brain injury, ocular disease, and surgery. The condition involves multiple disciplines, including ophthalmology, pediatrics, neurology, and rehabilitation. This complicates diagnosis and management.

Despite increasing international focus on this disorder, numerous deficiencies persist in its diagnosis and treatment within China. Clinicians often have limited awareness of VIPD. Diagnostic procedures are not standardized, and rehabilitation approaches remain inconsistent. Visual abnormalities may be overlooked in pediatrics and neurology. In contrast, ophthalmology has limitations in managing disorders related to cerebral pathology. In light of this, the present guideline has been developed based on European and American experiences, supplemented by local research and practice. It provides practical and systematic guidance for the diagnosis and management of VIPD. This aims to enhance diagnostic and therapeutic standards, foster multidisciplinary collaboration, and ultimately improve patients' visual function and quality of life.

Basic Concepts of Visual Information Processing Disorders

Definitions of visual information processing and visual information processing disorders VIP refers to the brain's ability to extract, organize, and interpret visual information from the environment and integrate it with other sensory and cognitive processes[1]. Its key components include visuospatial ability, which enables accurate perception of object position, direction, and distance[2]. Visual analytical skills include graphic recognition, detail discrimination, visual attention, and visual memory[3]. Additionally, visual-motor integration skills, which coordinate visual perception with bodily movements, are crucial for fine motor skills such as writing, drawing, and manual manipulation[4]. These three abilities are interrelated and synergistic, collectively supporting an individual's complex visual behavior and cognitive activities.

VIPD is defined as impairment in one or more components of the visual information processing system. The severity of impairment varies across individuals. This impairment disrupts an individual's normal visual cognitive and behavioral functioning, leading to multiple dysfunctions in daily life, educational, and occupational contexts[5].

Classification of visual information processing disorders This guideline classifies VIPD based on onset period and lesion location into four subtypes. This framework clarifies both disease progression and lesion location. It reduces category overlap and facilitates clinical diagnosis and targeted intervention. The detailed classification system is summarized in Table 1[6-12], and each subtype is described below.

Developmental visual information processing disorder Developmental visual information processing disorders (DVIPD) specifically arises during the critical period of visual system development (0–12 years old) in children. It is caused

Table 1 Classification system of VIPD

Classification	Abbreviation	Core definition	Onset period	Primary etiology	Typical clinical manifestations	Key differential features
Developmental VIPD	DVIPD	VIP dysfunction caused by abnormal development of the visual system or brain during the critical period of visual development	0–12 years old (critical period of visual development)	Congenital ocular anomalies (strabismus, amblyopia, nystagmus); neurodevelopmental disorders (cerebral palsy, autism spectrum disorder, neurodevelopmental delay)[6-8]	Gradual onset, progressive impairment of learning and motor skills; often accompanied by global developmental delay; symptoms appear synchronously with visual developmental milestones[9]	Onset before 12 years old; no clear history of trauma, surgery or acquired encephalopathy; normal visual function at birth with subsequent deterioration
Acquired ophthalmological VIPD	A-OVIPD	VIP dysfunction caused by acquired damage to ocular structures or functions	Any age after birth	Ocular trauma; acquired ocular infections; ophthalmic surgery (cataract extraction, glaucoma surgery, retinal detachment repair); acquired retinopathy[10-11]	Acute onset; clear temporal correlation with ocular injury/surgery; visual impairment correlates with the severity of ocular lesions[10-11]	Abnormal ophthalmic examination results; normal brain imaging; no pre-existing visual processing deficits before the triggering event
Acquired cerebral VIPD	A-CVIPD	VIP dysfunction caused by acquired damage to the brain's visual pathways or centers	Any age after birth	Traumatic brain injury; cerebrovascular accidents; brain tumors; encephalitis; brain surgery[10,12]	Acute onset; clear temporal correlation with brain injury/disease; severe visual cognitive impairment disproportionate to visual acuity[10,12]	Normal anterior and posterior segment ocular examination; abnormal brain imaging (MRI/CT); no pre-existing visual processing deficits before the triggering event
Congenital cerebral VIPD	C-CVIPD	VIP dysfunction caused by congenital malformations of the brain's visual system	Birth onset	Congenital brain malformations affecting the visual cortex or optic pathways; perinatal brain injury[12]	Symptoms appear in early infancy; often accompanied by other neurological deficits; stable or slowly progressive course[12]	Normal ocular structure; abnormal brain imaging present at birth; no acquired triggering events

VIP: Visual information processing; VIPD: Visual information processing disorders; MRI: Magnetic resonance imaging; CT: Computed tomography.

by structural or functional abnormalities of the eye or brain. Common causes include strabismus, amblyopia, nystagmus, cerebral palsy, neurodevelopmental delay, and autism spectrum disorder[6-8]. These conditions impair the normal development of VIP[6-8]. In autism spectrum disorder (ASD), VIP impairment often develops progressively during early learning and motor development, affecting overall development[9]. Notably, DVIPD is distinguished from acquired subtypes by its onset during the developmental critical period and the absence of a clear acute triggering event.

Acquired ophthalmological visual information processing disorder Acquired ophthalmological visual information processing disorder (A-OVIPD) is caused by acquired ocular damage that directly interferes with optical imaging or neural signal transmission within the eye, leading to deviations or losses in visual information at the initial stage of vision[11]. Primary etiologies include ocular trauma, acquired ocular infections, and ophthalmic surgeries such as cataract extraction, glaucoma treatment, and retinal detachment repair[10]. The onset time is well-defined and closely associated with the specific ocular injury or surgical event, and patients have normal visual processing function before the incident.

Acquired cerebral visual information processing disorder Acquired cerebral visual information processing disorder (A-CVIPD) is caused by acquired ocular damage that disrupts visual input at the level of the eye[12]. Predominant causes include traumatic brain injuries from car accidents or falls, cerebrovascular accidents, brain tumors, encephalitis, and brain surgery[10]. The onset is acute, with a clear temporal correlation to the brain injury event. A key feature is that significant visual cognitive impairment occurs even when the structure of the eye remains completely intact.

Congenital cerebral visual information processing disorder Congenital cerebral visual information processing disorder (C-CVIPD) is caused by congenital developmental defects of the brain's visual system, such as congenital brain malformations affecting the visual cortex or retrochiasmal visual pathways, or perinatal brain injury[12]. Symptoms are present from birth or appear in early infancy, and the disease course is usually stable or slowly progressive. It is differentiated from DVIPD by the presence of congenital brain structural abnormalities and the absence of normal visual development after birth.

Clinical Manifestation

Visuospatial impairment Patients with AVIPD often experience severe deficits in spatial cognition, encountering difficulties in recognizing the orientation, distance, and relative position of objects in space. In daily life, patients may have difficulty navigating, including following maps or remembering routes. Additionally, the patient struggles with organizing objects, as they are unable to arrange them neatly or assess appropriate spacing. When it comes to learning geometric shapes, the patient finds it challenging to comprehend and recognize spatial structures, such as differentiating between triangles and quadrilaterals. This significantly impairs their ability to learn mathematics and geography, as well as their capacity for independent travel and self-care[13].

Impaired visual analytical skills The patient exhibits graphic perception disorder, characterized by a slow perception of both overall and detailed features of graphics. This condition results in frequent errors in recognizing complex shapes and distinguishing between similar forms, such as circles and ovals or subtle differences between letters and numbers. Consequently, the patient faces substantial difficulties in reading charts and interpreting information conveyed through graphic symbols, which hinders their comprehension of learning materials and access to information.

Visual attention deficit is characterized by reduced sustained attention and increased distractibility. Patients may skip words, omit lines, or miss key visual details during reading or observation. This condition results in reduced learning efficiency and significantly impacts classroom learning and reading activities[14].

Visual memory impairment is characterized by the immediate forgetting of objects, images, or textual information, making it challenging to establish a stable visual memory. Furthermore, individuals with visual attention deficits often exhibit poor performance in acquiring new knowledge, reviewing previously learned material, or executing visual recall tasks (*e.g.*, recalling observed scenes or the appearance of individuals), which severely hinders knowledge accumulation and cognitive development[15].

In the context of low visual cognition, individuals with autism spectrum disorders, such as autism, experience challenges in visually communicating emotions. Research by Bertone and colleagues indicates that while individuals with autism perform comparably to typically developing individuals [matched for age and intelligence quotient (IQ)] in processing simple visuospatial stimuli, they exhibit significant impairments when processing more complex stimuli.

Visual-motor integration disorder There exists a significant disparity between fine motor skills and visual perception, characterized by awkward and unstable pen grips, erratic scribbling, misaligned strokes, and inconsistent spacing in writing. Individuals experience pronounced difficulty in tasks such as copying from boards or graphs. Furthermore, when participating in activities that require hand-eye coordination, such as handicrafts and ball games, their movements are often clumsy and slow, with an inability to accurately adjust body movements based on visual cues. This deficiency severely impacts their academic performance, motor skill development, and reduces their engagement in life skills and social activities[16].

Diagnostic Process

History taking and questionnaires Detailed inquiries should cover the patient's birth history (*e.g.*, prematurity, labor complications, low birth weight, neonatal asphyxia, jaundice) and growth/developmental history (*e.g.*, visual milestones such as age of first gaze, visual tracking, object recognition; and progression of motor and cognitive development). Additionally, the patient's history of previous illnesses is examined, covering ocular, cranial, cerebral, and systemic conditions along with their treatments. The history of traumatic injuries and surgeries, particularly those involving the head and eyes, is also considered. Furthermore, the family genetic history is reviewed to identify any close relatives with visual or neurological disorders[17].

The selection of questionnaires was meticulously tailored to the patient's age and visual acuity. For infants and toddlers aged 0–2y, the Preverbal Visual Assessment (PreViAs) questionnaire was employed to focus on early visual responses and behaviors. For children aged 3–5y, the Flemish Cerebral Visual Impairment Questionnaire (FCVIQ) was utilized to conduct a comprehensive assessment of visual cognitive functioning. The Parent Questionnaire for Children under 6 years old (PQCVI) was used to gather information on children's visual behaviors from the parents' perspective. For children aged 5–12y with severe visual impairment, the Visual Skills Inventory (VSI) was administered. The Cerebral Visual Impairment Questionnaire (CVIQI) and its five screening questions were used for children with visual acuity ≥0.1, while the Higher Visual Functional Impairment Questionnaire (HVFQI51) was applied to those with visual acuity ≥0.4, providing a multidimensional assessment of visual functioning across different levels of visual acuity. Additionally, the Structured Clinical Question Inventory (SCQI) was used for individuals under 18y to offer a comprehensive assessment of the visual status of young people. The SCQI was employed for individuals under 18 years of age to thoroughly evaluate the visual status of adolescents, ensuring that the questionnaire results accurately reflect the patients' VIP abilities and potential issues[18].

Symptoms and signs Observations of limb coordination problems are conducted by assessing the patient's daily activities, such as their coordination and balance during physical exercises (*e.g.*, running, jumping, ball games), proficiency in daily living skills (*e.g.*, dressing, tying shoelaces, using utensils), and accuracy in tasks requiring two-handed collaboration (*e.g.*, building blocks, paper folding). Additionally, frequent movement errors, imbalance, and poor hand coordination may indicate the presence of VIPD These physical coordination challenges are attributed to disorders in VIP[19].

Direction recognition disorder involves assessing a patient's ability to perceive directions through simple instructional tests, such as identifying left and right, up and down, recognizing the orientation of a map or spatial layout, and discerning the directionality of alphanumeric characters (*e.g.*, identifying mirror writing or reversed writing). Persistent errors in these tasks indicate an impairment in visuospatial direction recognition[20].

Similarly, similarity discrimination disorder pertains to the comparison of objects with similar attributes, such as color, shape, and size (*e.g.*, distinguishing between colored blocks of different shades, geometric shapes on cards, or stationery items of varying sizes but similar appearance), as well as numerical characters (*e.g.*, differentiating between numbers like 6 and 9, or letters like b and d). Difficulty in accurately distinguishing these elements reflects deficits in visual analytical discrimination ability[21].

Impaired recognition of graphic background: When an individual is presented with an image containing a target graphic amidst a complex, distracting background—such as an animal silhouette obscured by a tangle of lines or a specific symbol embedded within numerous similar patterns—and is tasked with identifying the target, a failure to do so within the designated time or the occurrence of frequent errors indicates a deficiency in the ability to discern graphic backgrounds[22].

Impaired visual closure: In tasks involving jigsaw puzzles, ranging from simple geometric configurations to intricate scene puzzles, or in partial occlusion recognition tests—where a partially obscured image of a common object is shown and the individual is asked to identify it—difficulty in completing these tasks suggests a dysfunction in visual closure. This dysfunction impairs the perception and integration of the overall visual image[23].

Impaired visual memory is assessed by presenting a series of objects, graphics, or text sequences to the patient, who is then asked to recall and describe the content after a brief interval. A low recall accuracy, characterized by significant omissions, suggests a dysfunction in the visual memory system, which adversely affects knowledge acquisition and experiential learning[24].

Impaired visuomotor integration is evaluated by observing the patient's writing process, including font shape, stroke order, writing speed, and fluency, as well as their ability to accurately replicate simple to complex shapes (*e.g.*, geometric shapes, sketches) and perform basic manual drawing tasks (*e.g.*, drawing straight lines, circles, simple patterns). Poor quality in writing and drawing, coupled with uncoordinated hand-eye movements, indicates deficient visuomotor integration[25].

Impaired visual-auditory integration is evidenced when a video featuring disparate sounds alongside corresponding object images or actions is presented, and the individual is required to promptly identify the observed objects or actions. A delayed response and elevated recognition error rate indicate a disruption in the integration and processing of visual and auditory information, thereby impairing the ability to synthesize multisensory information and respond swiftly[26].

Inspection and evaluation methods

1) Eye exam Visual acuity and refractive status: For routine visual acuity screening, alphanumeric or numeric visual acuity charts are typically utilized; however, the Teller visual acuity card is recommended for patients with severe VIPD. These assessments are complemented by the use of optokinetic nystagmus and selective viewing techniques to effectively evaluate vision in infants, toddlers, and children with cognitive and language disorders. For children under the age of seven at their initial visit, a three-day dilation using 1% atropine ophthalmic ointment is recommended to accurately assess refractive error. In cases involving strabismus, the dilation period should be extended to 3–7d to ensure the reliability of results, which serve as a foundation for subsequent treatment[27].

Slit Lamp Examination: Utilizing a slit lamp microscope enables a detailed and comprehensive evaluation of the external ocular structures, including the eyelids, conjunctiva, cornea, anterior chamber, iris, and lens. This examination facilitates the detection of inflammation, injuries, congenital anomalies (such as congenital cataracts and iris defects), and degenerative diseases. It is instrumental in assessing the integrity and health status of the anterior segment of the eye and in promptly identifying potential sources of ocular pathology that may impact VIP[28].

Fundus Examination: Employing direct fundoscopy or fundus photography provides a clear visualization of the internal structures of the eye, including the vitreous humor, choroid, retina, and optic nerve. Additionally, optical coherence tomography offers high-resolution images of the retinal layers and optic nerve fibers, allowing for the precise detection of retinopathies (such as retinal detachment and macular degeneration) and optic nerve diseases (such as optic neuritis and optic nerve atrophy)[29-30]. This examination is crucial for elucidating the condition of the posterior segment of the eye and understanding the impact of lesions on visual signaling[31].

Examination of Eye Position and Movement: For infants and young children with varying levels of cooperation, the corneal reflection test employs the principle of light reflection to evaluate eye position, making it suitable for young children who are uncooperative. The alternating cover test assesses eye movement by alternately covering each eye to determine the presence and type of strabismus. The “doll’s head” maneuver evaluates compensatory eye movements by rotating the patient’s head to assess ocular motor function. The “doll’s head” maneuver is conducted by rotating the child’s head to observe compensatory eye movements, thereby evaluating ocular motility. Additionally, children capable of cooperating may undergo standard eye movement examinations to facilitate a comprehensive assessment of eye alignment and motility, as well as to identify factors affecting VIP, such as strabismus and nystagmus[32].

Examination of Visual Function: Depending on the child’s level of cooperation, traditional tools (such as adjustable reticles, dispersion spheres, and prisms) can preliminarily assess accommodation, dispersion, and eye movement functions. Digital devices (such as eye trackers and visual function training systems) offer precise and quantitative assessments of visual function parameters, providing comprehensive data to support the diagnosis and rehabilitation of VIP disorders, as well as analyzing the fundamental functional status of the visual system[33].

In an academic context, the sentence can be revised as follows: Visual electrophysiological assessments, including flash visual evoked potential (FVEP) and electroretinogram (ERG), are often used together. FVEP objectively evaluates visual sensitivity threshold in infants and young children, especially those unable to subjectively assess visual acuity. ERG assesses retinal photoreceptor and ganglion cell function. Combining both facilitates precise diagnosis of retinal and visual pathway abnormalities and helps identify lesions associated with VIPD[34].

2) Brain exam Electroencephalography (EEG): While not as commonly utilized as visual evoked potentials (VEP), EEG holds significant importance in specific cases, such as occipital lobe epilepsy resulting from damage to the occipital cortex. These patients often exhibit abnormalities in eye movement and visual perception disorders. Electroencephalography (EEG) is capable of detecting abnormal brain wave discharges, aiding in the identification of the underlying causes of neurological disorders, and providing electrical-level neurological data crucial for diagnosing VIPD. Additionally, EEG serves as a screening tool for assessing the impact of epilepsy and other electrophysiological brain disorders on vision[35].

In terms of imaging examinations, magnetic resonance imaging (MRI) offers high-resolution soft-tissue imaging, which is instrumental in elucidating the etiology of brain lesions, such as brain tumors, cerebral vascular malformations, cerebral white matter lesions, and congenital brain developmental anomalies, particularly within the visual pathway and associated brain regions. Furthermore, functional MRI and diffusion tensor imaging techniques are valuable for detecting brain functional activities and assessing the integrity of nerve fiber bundles, enabling the early detection of small lesions or nerve fiber damage[8,36]. Functional magnetic resonance imaging and diffusion tensor imaging are instrumental in detecting both the functional activity of the brain and the integrity of nerve fiber tracts[8,37]. These imaging modalities can identify small foci or early-stage damage to nerve fibers, thereby facilitating an analysis of the pathological basis of brain-originated visual VIPD from both structural and functional perspectives. This analysis is crucial for guiding precise diagnosis and the development of treatment plans[38].

Visual information processing assessment The Piaget left-right awareness test involves the design of various tasks, such as arranging left-right symmetrical objects, manipulating toys according to left-right commands, and assessing changes in the left-right position of objects after rotation or mirroring. These tasks aim to deepen the understanding of the formation of left-right concepts and the cognitive abilities related to spatial rotation and mirroring. The test provides critical indices for accurately assessing the recognition of left-right direction and the processing of spatial orientation relationships, thereby serving as a key diagnostic tool for visuospatial ability[39].

Jordan's left-right reversal test and Gardner's reversal frequency test involve presenting letters, numbers, and shapes in various orientations to children, who are then asked to identify normal and reversed patterns. By counting the frequency of reversal errors, these tests effectively evaluate children's perceptual acuity and the stability of their spatial orientation of objects. This assessment reflects the accuracy and consistency of their visuospatial orientation recognition and processing abilities, and aids in diagnosing visuospatial cognitive disorders, including their type and degree.

The stereoscopic rotation test involves providing children with various stereoscopic object models or virtual three-dimensional shapes to observe and mentally rotate. Children are then tasked with answering questions regarding the number of surfaces and the relationships between neighboring surfaces. This test comprehensively evaluates children's spatial imagination, visual transformation, and three-dimensional spatial cognitive abilities. It assesses the depth and breadth of visuospatial information processing through complex spatial tasks, thereby providing multi-dimensional spatial ability data for diagnostic purposes.

Assessment of visual analytical skills The developmental test of visual perception (DTVP) is a paper-and-pencil assessment designed to evaluate five fundamental domains: eye-movement coordination, pattern-background constancy, shape perception, spatial location, and spatial relationships. The test materials are diverse and include test cards with varying levels of shape and pattern complexity. During the test administration, children are observed as they perform tasks that assess eye movement trajectory, speed and accuracy of pattern recognition, and the ability to identify a target amidst background interference. This allows for an accurate and quantitative evaluation of children's perceptual development. The DTVP is particularly suitable for children with learning difficulties or neurological disorders, providing a systematic and comprehensive assessment for diagnosing visual analytical abilities and analyzing strengths and weaknesses across various dimensions[40].

The test of visual perceptual skills (TVPS) comprises seven subtests, each featuring a presentation board and specific test items. The test includes activities such as graph matching, visual discrimination, and spatial relationship judgment, and is appropriate for individuals aged 5 to 21y, with a duration of approximately 25 to 40min. The test is administered and scored following a standardized protocol, enabling the acquisition of a comprehensive score reflecting the patient's visual perceptual skills and performance across various sub-domains. This approach facilitates an in-depth analysis of the patient's specific characteristics and the development of visual analytical skills, thereby providing a detailed foundation for individualized diagnosis and intervention[41].

In assessing visual-motor integration ability, the visual-motor integration development test (VMI) employs 24 geometric shapes, ranging from simple to complex, as test materials. Participants, including children and adults over the age of two, are required to replicate these shapes through drawing. During the assessment, observations are made regarding the patient's pencil grip, line drawing fluency, accuracy in graphic reproduction, and proportional coordination. This comprehensive evaluation of visual-motor integration ability reflects the individual's level of eye-hand coordination and fine motor skills. It effectively screens for visual-motor issues related to learning and behavioral disorders, providing a quantitative basis for diagnosing visual-motor integration disorders and developing rehabilitation training programs[42].

The slight cognitive impairment test (SCIT) is an assessment tool designed to evaluate VIP, particularly under time constraints affecting processing efficiency. The SCIT is derived from the inspecting time (IT) task, a computerized perceptual judgment task where participants determine which of two perpendicular lines is shorter (left or right) and indicate their choice by pressing a timed button. The target stimulus is backward masked and presented over exposure times ranging from 16 to 176ms, in 16-ms increments. The SCIT is sensitive to subtle changes in cognitive function, requires only a few minutes to administer, and provides measures of both response time (processing speed) and accuracy (processing efficiency). It is suitable for use with individuals aged 7 to 90y in both clinical and community settings[42].

Table 2 Differential diagnosis of VIPD

Condition	Key differential features
Uncorrected refractive error	Best-corrected visual acuity returns to age-appropriate normal levels; all VIP function deficits resolve completely after accurate refractive correction[27]
Global intellectual disability	Generalized cognitive impairment affecting multiple domains rather than isolated visual processing; visual function deficits are proportional to overall cognitive decline[5]
ADHD	Primary deficit lies in attention regulation and impulse control; visual processing abnormalities are secondary to inattention and improve with evidence-based ADHD management; no structural or functional abnormalities in the visual pathway[14]
Primary motor disorder (*e.g.*, developmental coordination disorder)	Motor impairment is primary and unrelated to visual perception deficits; performance on pure visual perceptual tasks (without motor demands) is within normal limits[25]
CVI	Severe, bilateral visual dysfunction caused by damage to the retrochiasmal visual pathways or visual cortex; often associated with additional neurological deficits; VIPD may be a component of CVI but represents a milder, more isolated form of visual processing dysfunction[12,35]

VIPD: Visual information processing disorders; ADHD: Attention deficit hyperactivity disorder; CVI: Cerebral visual impairment.

Diagnostic Criteria and Differential Diagnosis

Core diagnostic criteria A definitive diagnosis of VIPD is established when all of the following mandatory criteria are met.

1) Documented functional impairment: Objective evidence of deficits in at least one of the three core domains of VIP: visuospatial abilities, visual analytical skills, or visuomotor integration, as identified *via* clinical observation and standardized assessment tools[13-26].

2) Functional impact: The identified impairment significantly interferes with the individual's daily living activities, academic performance, occupational functioning, or social participation[5,13].

3) Exclusion of primary confounding conditions: The impairment cannot be fully attributed to uncorrected refractive errors, isolated low visual acuity, general intellectual disability, or primary sensory deficits unrelated to visual processing[11-12].

4) Objective supportive evidence: Abnormal findings on at least one objective diagnostic modality, including comprehensive ophthalmic examination, neuroimaging, or electrophysiological testing, that correlate with the clinical presentation[27-42].

Auxiliary diagnostic criteria The presence of any of the following criteria provides supportive evidence for the diagnosis of VIPD, though they are not sufficient for a definitive diagnosis in the absence of core criteria.

1) A positive clinical history of risk factors, including developmental anomalies, traumatic brain injury, ocular disease, or ophthalmic/neurological surgery with a clear temporal correlation to symptom onset[6-12,17].

2) Abnormal scores on age-appropriate, validated VIP assessment questionnaires, or quantitative functional tests[18,39-42].

3) Clinically significant improvement in core symptoms and functional abilities following a standardized, targeted visual cognitive rehabilitation program.

Differential diagnosis VIPD must be differentiated from the following conditions that may present with overlapping clinical features (Table 2)[5,12,14,25,27,35].

Diagnostic algorithm The diagnosis of VIPD follows a standardized, stepwise algorithm aligned with clinical practice[17-42].

Step 1: Initial screening conduct comprehensive history taking+basic ophthalmic examination+targeted clinical symptom assessment to identify patients at risk for VIPD[17,27-28].

Step 2: Functional evaluation administer age- and acuity-appropriate standardized VIP questionnaires and objective functional tests to quantify the type and severity of visual processing deficits[18,39-42].

Step 3: Etiological diagnosis perform neuroimaging and electrophysiological testing to localize the lesion and distinguish between ophthalmological (OVIPD) and cerebral (CVIPD) subtypes[12,34-38].

Step 4: Classification and severity grading classify the VIPD subtype according to the classification system and grade the severity of functional impairment based on the degree of interference with daily activities[6-12].

Step 5: Multidisciplinary consultation refers complex cases to a multidisciplinary team including ophthalmologists, pediatricians, neurologists, and rehabilitation specialists for comprehensive evaluation.

Visual Cognitive Rehabilitation

Ophthalmic treatment General treatment for refractive errors involves providing patients with appropriately prescribed eyeglasses following precise optometric evaluation. This ensures accurate focusing of light on the retina, thereby enhancing visual clarity and establishing a clear image foundation for VIP. For patients experiencing reduced vision in one or both eyes, refractive error correction is implemented alongside occlusion therapy. The duration and method of occlusion are adjusted based on the progress of visual acuity recovery, aiming to stimulate the development of the amblyopic eye. In cases of constant strabismus, refractive errors are corrected, and occlusion therapy is administered for 6mo. Subsequently, strabismus correction surgery is performed once the visual function of both eyes is initially balanced. This approach aims to restore the parallel alignment of the visual axes, promote binocular visual integration, and reconstruct stereoscopic function. Ultimately, this treatment strategy seeks to optimize the optical and neurophysiological conditions of the eye, thereby enhancing the foundational hardware for VIP[43].

For patients with cognitive and motor disabilities who face challenges in actively engaging in visual training, computer-assisted visual stimulation platforms offer significant advantages. Computer-assisted visual stimulation platforms use a checkerboard flip mode (passive stimulation), dynamic light and shadow, color-changing modes, and auditory feedback (*e.g.*, sound cues, musical rewards). These features capture patients' attention and enhance visual nerve excitability. Clinical evidence supports the efficacy of this approach in significantly improving the visual sensitivity of children across various age groups, thereby enhancing the quality of visual information input. This method serves as a crucial adjunct in visual rehabilitation, particularly during the early stages of rehabilitation or for patients exhibiting low compliance with active training[44].

Visual performance training Visual performance training aims to optimize various aspects of visual function, including eye movement (gaze accuracy, smooth pursuit, and saccadic agility), accommodation (lens convexity and flattening), and convergence-divergence (coordination of binocular vision axes). This is achieved through the use of specialized training equipment, such as eye movement trainers, accommodation training lens sets, and convergence-divergence training tools, alongside targeted training programs. These programs may include gaze stability exercises with static and dynamic targets, pursuit training using moving reticle tracking, scanning exercises for rapid visual search tasks, accommodation training involving alternating focus between distant and near objects, lens gradient switching exercises, and convergence-divergence training for binocular fusion and stereopsis enhancement. The overall goal is to fortify the visual system and improve visual performance. Additionally, the fundamental functions of the visual system are reinforced through stereopsis and stereoscopic training. Following systematic training, the efficiency of VIP in patients with mild illness can be significantly enhanced, leading to the alleviation or elimination of most symptoms[45].

Visual Information Processing Training

Developing visuospatial skills Bilateral integration training: Develop tasks that require bilateral synchronization or alternation, such as simultaneously observing and comparing features of objects within the left and right visual fields, tracking visual targets that move bilaterally, or manipulating distinct shapes of blocks with both hands to arrange them according to specific spatial rules. These activities aim to facilitate the synergistic processing and integration of visual information from both hemispheres of the brain, thereby enhancing overall visual-spatial perception and manipulation capabilities.

Lateralization training involves unilateral visual stimulation and task practice, such as occluding one eye to perform tasks related to graph recognition and spatial localization. This approach aims to strengthen the brain's capacity to process unilateral visual information, thereby improving the functional specificity of lateralized vision. It addresses spatial cognitive biases resulting from neglect or uneven functioning of lateralized vision and enhances the accuracy of visuospatial judgment.

Orientation training: Implement exercises such as map navigation simulations, direction sign recognition, and spatial direction change tracking to improve the patient's sensitivity and accuracy in recognizing directional information across various environments. These activities are designed to cultivate the ability to quickly and accurately judge orientation in complex spatial scenarios, optimize visuospatial orientation skills, and mitigate instances of directional disorientation and spatial confusion[46].

Developing visual analysis skills Visual discrimination training involves tasks that utilize a large number of similar graphics, color, and texture comparisons. These tasks range from identifying simple graphic differences (such as subtle distinctions between round and oval shapes) to recognizing complex patterns (such as trademarks with interfering elements). This training progressively enhances the patient's ability to discern visual details, thereby improving the acuity and accuracy of the visual analysis system, and establishing a foundation for complex VIP.

Visual graphic background training involves presenting multi-level graphic background interference scenes, such as targets like animals or numbers concealed within dense lines or similar patterns. Patients are required to quickly and accurately identify these targets, which exercises their ability to distinguish between figures and backgrounds, enhances the focus of visual attention, optimizes the allocation of selective attention, and improves the efficiency of extracting key information in complex visual environments.

Visual closure training: This involves systematically increasing the complexity of puzzles, progressing from simple graphic puzzles with few pieces to intricate scene puzzles with numerous pieces. This is coupled with exercises that require the recognition of objects despite partial occlusion, such as identifying the outline of a car partially obscured by foliage. The aim is to enhance visual closure abilities, thereby promoting the brain's capacity to construct and predict the completeness of visual information, and to improve overall visual image perception and comprehension.

Visual memory training: This training employs a variety of visual memory tasks, such as memorizing sequences of geometric shapes, details of scenes, and combinations of characters. The difficulty is progressively increased by extending the duration of memory retention and the volume of information to be memorized. This is complemented by recall and recollection tests, which are designed to train the encoding, storage, and retrieval processes of visual memory. The goal is to improve both short-term and long-term memory effects related to visual information, thereby enhancing learning and cognitive abilities.

Visualization skills training involves engaging in imaginative construction tasks, such as generating three-dimensional structures, spatial layouts, or movement trajectories of objects based on descriptions, as well as envisioning graphic transformations (*e.g.*, visualizing the shape of a square after rotation). This training aims to develop the ability to generate and manipulate visual representations, thereby enhancing the flexibility and creativity of visual thinking and facilitating the resolution of complex visual problems and spatial reasoning tasks[47].

Developing visual-motor skills General hand-eye coordination training begins with simple activities, such as threading beads, throwing a ball into a basket, and picking up small objects with chopsticks. It gradually progresses to more intricate manipulations using tools (*e.g.*, assembling a small model with a screwdriver). This training is conducted at varying speeds, distances, and angles to improve the real-time coordination of hand movements and visual feedback, thereby enhancing the precision and fluency of hand-eye movements. Ultimately, it aims to improve operational abilities in daily life and work.

Efficient training in visual motion ergonomics involves a comprehensive analysis of a patient's movement posture, exertion patterns, and visual focus trajectories during activities such as writing, drawing, and crafting. By providing guidance on postural correction, suggesting adaptations to tools (*e.g.*, selecting appropriate pen grips), and optimizing operational processes, this training aims to minimize unnecessary movements and visual search paths. Consequently, it enhances the efficiency of visual motion energy utilization, accelerates task completion, and mitigates fatigue and injury risks.

In parallel, precise and rapid training in visually guided fine motor control is facilitated through the use of electronic devices (such as high-precision touch-screen drawing tools and micromanipulation simulation software) or miniaturized models. These tools are employed to create tasks with specific time constraints and accuracy requirements, thereby training patients to swiftly and accurately manage fine hand movements under visual guidance. This includes tasks such as drawing intricate line patterns and assembling small mechanical components, ultimately improving the speed and precision of visuomotor control to meet the demands of complex tasks.

Designing training for visually-guided motor actions involves preparing patients for complex multi-step assembly tasks, such as constructing intricate structures with blocks or assembling mechanical models, as well as motor sequence tasks, like executing a game of chess by strategically moving pieces. Prior to task execution, patients must observe the overall structure and meticulously plan the operational steps, making necessary adjustments based on visual feedback during the process. This approach aims to cultivate visuomotor prospective planning and dynamic adjustment skills, thereby enhancing the quality and efficiency of task completion.

Enhancement of complex spatial pattern reproduction: To improve patients' ability to comprehend, memorize, and reproduce complex spatial information, it is recommended to provide them with examples of intricate spatial patterns, such as three-dimensional geometric structures and architectural blueprints. Patients can then utilize corresponding materials, such as blocks and modeling materials, to engage in three-dimensional reconstruction. Additionally, employing virtual reality technology to simulate complex spatial environments can facilitate the practice of navigation and operational skills, thereby enhancing spatial cognition and practical abilities.

Development of skill automaticity: To cultivate the automaticity of visual processing skills, it is essential to design a series of repetitive and comprehensive visual task exercises. These exercises should include combinations of visual discrimination, spatial localization, and hand-eye coordination tasks, to be completed within a limited timeframe. By progressively reducing reaction times and enhancing operational precision through increased practice, the transformation of VIP from conscious control to unconscious automation can be achieved. This approach aims to foster rapid, accurate, and fluent visual cognition and motor responses, thereby enhancing adaptability and efficiency in both real-life situations and learning scenarios[48].

Traditional Chinese Medicine Acupuncture therapy[49] integrates the traditional Chinese medicine theories of visceral organs and meridians with the western medical concept of brain vision. This approach primarily involves the selection of acupoints around the eyes, head, and limbs, such as Eyeming, Zanzhu, Sun, Sibai, Baihui, Fengchi, Feiming, scalp acupuncture visual area, Hegu, Bright, Taichong, and Taixi. The aim is to stimulate the meridians and the flow of Qi and blood, thereby regulating the function of the oculovisceral apparatus and vision-related visceral organs. Additionally, it facilitates the remodeling and development of the impaired visual brain, enhancing the brain's ability to receive and process visual information. Clinical studies have demonstrated that acupuncture therapy, when combined with conventional visual stimulation techniques for fine visual training (such as black and white stripe deletion training and posterior image red light training), can improve the latency (P100-L) and amplitude (P100-A) of pattern visual evoked potentials (P-VEP) in children aged 3 to 10y. This combined approach promotes the recovery of optic nerve conduction function and improves best-corrected visual acuity, showing greater efficacy than conventional visual stimulation therapy alone. The integration of acupuncture therapy with traditional visual stimulation offers a comprehensive and effective approach to visual rehabilitation by harmonizing the organism's Qi, Blood, Yin, and Yang balance, thereby augmenting the visual system's self-repair capabilities.

Low Vision Rehabilitation

Sensorimotor rehabilitation Tactile training: Engaging in tactile training involves interacting with objects of varying shapes, textures, and temperatures, such as sandpaper texture boards, plush toys, and hot and cold compresses, and performing tasks like shape recognition, texture description, and temperature perception. This approach aims to enhance tactile sensitivity and memory by integrating tactile and visual information, thereby aiding patients in perceiving their environment and the characteristics of objects. Consequently, this training can improve spatial cognition and manipulation abilities.

Auditory training: Auditory training encompasses exercises in sound orientation, timbre discrimination, and rhythm and sequence memory. Activities may include identifying the direction of sounds, recognizing different musical instruments, and memorizing melodies' rhythms. This training is designed to enhance auditory spatial perception and information processing capabilities. By compensating for visual impairments with auditory information, patients can improve their environmental perception and safety, navigating and identifying objects through auditory cues in daily life.

Taste and smell training involves activities such as taste discrimination, where individuals distinguish between different flavors in solutions and foods, and smell recognition, which includes identifying various flowers, fruits, and everyday odors. Additionally, taste and smell correlation memory training is employed, where individuals recall the combination of smells and flavors associated with specific foods. These exercises aim to enrich sensory experiences and enhance information acquisition channels, thereby improving the individual's perception of their surroundings and attention to detail. This training is particularly beneficial for individuals with low vision, as it aids in their cognitive engagement with life and participation in activities.

Residual vision training leverages the patient's remaining visual capabilities to conduct visual enhancement exercises. These include recognizing enlarged visual targets, such as large-print reading and identifying large-size figures, and engaging in high-contrast visual tasks, like tracking black and white checkerboards or observing object contours under bright light. Additionally, visual field expansion exercises, such as eyeball rotation scanning training and peripheral visual stimulation, are employed to maximize the utilization and enhancement of residual visual function. The goal is to optimize the efficiency and quality of visual information acquisition.

Kinematic training encompasses proprioceptive exercises, such as standing on one foot, walking with eyes closed, and adjusting limb position sense, alongside motor coordination activities, including basic gymnastics, rope skipping, and fundamental ball game movements. These exercises aim to enhance the patient's balance, motor coordination, and spatial awareness, thereby improving motor control and ensuring safer activities in environments with low visibility. This training also seeks to mitigate the risk of motor imbalance and injuries associated with visual impairments.

Initial cognitive rehabilitation training involves engaging patients in basic cognitive exercises focused on numbers, words, colors, and shapes. Activities such as number sorting, word recognition and spelling, color sorting, and shape matching are conducted using large font, high-contrast materials, and auxiliary tools like magnifying glasses and electronic visual aids. These exercises are integrated with multi-sensory teaching methods, such as tactile interaction with numerical models and auditory and visual word recognition, to gradually restore and enhance the patients' foundational cognitive abilities. This approach establishes a foundation for continued learning and self-care, while enhancing the information processing and knowledge acquisition capabilities of individuals with low vision.

In the domain of life skills rehabilitation, systematic instruction and hands-on practice will be implemented for daily activities such as dressing, washing, eating, cooking, and home organization. This includes guidance on clothing identification and buttoning sequences for dressing, as well as instruction on ingredient handling and fire control in cooking. The use of tactile labels, voice prompting devices, specialized tableware, and kitchen utensils, along with other assistive tools, will aid patients in mastering independent living skills, thereby improving their self-care, quality of life, and social participation.

Furthermore, orientation and mobility rehabilitation will be conducted in a secure environment, encompassing both indoor and outdoor training. This will involve skills development in areas such as walking in a straight line, turning, navigating stairs, and avoiding obstacles, ultimately contributing to enhanced quality of life, increased social participation, and bolstered self-confidence. Through the integration of assistive devices, including white canes, guide dogs, and electronic navigation tools, along with the instruction in recognizing environmental cues such as sounds, smells, and tactile landmarks (*e.g.*, roadside rails, tactile signage on doorways), we enhance patients' abilities to travel safely and independently. This approach broadens their range of activities, improves social interactions, and increases convenience in daily living. Additionally, the program is structured to improve social interaction and facilitate daily living[50].

Individual Correction In terms of physical therapy, interventions such as massage, rehabilitation exercises, and postural correction training are implemented to alleviate muscle pain and fatigue, enhance body mechanics, prevent secondary injuries, and improve overall comfort and mobility. These interventions address issues like abnormal postures (*e.g.*, hunching, head tilting) and muscle imbalances (*e.g.*, tension or weakness in the neck, shoulders, and lower back) that arise from prolonged low vision.

Occupational therapy involves assessing and training individuals with low vision in occupational skills tailored to their age, interests, occupational preferences, and residual vision capabilities. This includes training in activities such as hand knitting, basic mechanical maintenance, massage, and data entry. Additionally, recommendations are provided for adaptive equipment and modifications to the work environment, such as screen magnification, enhanced lighting, and customized tools, to facilitate occupational rehabilitation and re-employment. These interventions aim to improve the patients' socio-economic status and sense of self-worth[51].

Multidisciplinary Collaboration and Integrated Management The diagnosis, treatment, and rehabilitation of VIPD necessitate close multidisciplinary collaboration among specialists in ophthalmology, pediatrics, neurology, and rehabilitation. Ophthalmologists should prioritize the structural and functional assessment and treatment of the eye to address refractive errors and ocular pathologies. Pediatricians ought to focus on children's developmental history and environmental factors to identify developmental disorders at an early stage. Neurologists should examine brain lesions and analyze abnormalities in neural pathways. Rehabilitation specialists should develop personalized rehabilitation plans and provide training guidance. To ensure comprehensive and consistent treatment, the multidisciplinary team should conduct regular consultations, share patient information, and adapt strategies as the patient's condition changes[52].

A long-term follow-up mechanism is established to monitor the recovery of visual function, enhancement of life and learning abilities, and psychological well-being. Regular evaluations of rehabilitation outcomes are conducted to optimize the rehabilitation plan and adjust the intensity and content of training based on the assessment results. Concurrently, it is essential to address the psychological needs of patients by offering psychological support and counseling to alleviate anxiety, depression, and other negative emotions associated with visual impairment. This approach aims to enhance patients' confidence in rehabilitation, improve compliance, and facilitate comprehensive rehabilitation and social integration.

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Disclaimer: The contents of this guideline represent only the guidance of the experts involved in the development of this guideline for the reference of clinicians. Despite extensive consultation and discussion among experts, there are incomplete points. The recommendations provided in this guideline are not mandatory, and practices that are inconsistent with this guideline do not imply error or inappropriateness. There are still many issues to be explored in clinical practice, and ongoing and future clinical trials will provide further evidence. With the accumulation of clinical experience and the emergence of new treatments, this guideline will need to be revised and updated periodically in the future to bring more clinical benefits to the subjects.

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