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OPTOMETRIC CLINICAL PRACTICE GUIDELINE

Care of the Patient with

Learning Related Vision Problems

American Optometric Association®

OPTOMETRY:
THE PRIMARY EYE CARE PROFESSION

Doctors of optometry are independent primary health care providers who examine, dianose, treat, and manage diseases and disorders of the visual system, the eye, and associated strutures as well as diagnose related systemic conditions.

Optometrists provide more than two-thirds of the primary eye care services in the United States. They are more widely disribured geograpically than other ee care providers and are readily accessible for the delivery of eye and vision care services. There are approximately 28,200 full-time equivalent doctors of optometry currently in practice in the United States. Optomotrist practice in approximately 7,084 communities across the United States, serving as the sole primary eye care provider in more than 4,300 communities.

The mission of the profession of optometry is to fulfill the vision and eye care needs of the public through clinical care, research, and education, all of which enhance the quality of life.

CARE OF THE PATIENT WITH LEARNING RELATED VISION PROBLEMS

Reference Guide for Clinicians

Prepared by the American Optometric Association Consensus Panel on Care of the Patient with Learning Related Vision Problems:

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NOTE: Clinicians should not rely on this Clinical guideine lone for patient care and management. Refer to the listed references and other sources for a more detailed analysis and discussion of research and parient care information. The information in the Guideline is current as of the date of publication. It will be reviewed periodically and revised as needed.

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INTRODUCTION

Optometry has a long history of caring for individuals with learning problems.[1-3] Parents, teachers, and therapists often seek diagnostic evaluation to determine whether a vision problem could be a factor contributing to learning problems. In addition, intervention strategies developed by optometry have been incorporated into conventional therapeutic approaches for these individuals. Thus, Doctors of Optometry function as members of a multidisciplinary team of health care practitioners and special education professionals in the comprehensive care of individuals with learning problems.[4,5] The Joint Organizational Policy Statement on Vision, Learning and Dyslexia addresses these issues (see Appendix 1).[6]

This Optometric Clinical Practice Guideline on Care of the Patient with Learning Related Vision Problems describes appropriate evaluation methods and management strategies to reduce the risk of vision problems' interference with the learning process. It contains recommendations for timely diagnosis, intervention, and, when necessary, referral for consultation and/or treatment by another health care provider or education professional. This Guideline will assist Doctors of Optometry in achieving the following goals:

- Diagnose visual information processing problems
- Improve the quality of care provided to patients with learning related vision problems
- Select appropriate evaluation instruments to evaluate learning related vision problems
- Select appropriate management strategies for patients with learning related vision problems
- Minimize the adverse effects of learning related vision problems and enhance quality of life
- Inform and educate other health care professionals, parents, teachers, and the educational system about the nature of learning related vision problems and the availability of treatment.

I. STATEMENT OF THE PROBLEM

A. GENERAL CONSIDERATIONS

1. Effects

The standards of learning competence required to meet changing societal needs and conditions are increasing. Full participation in science, technology, business, and the professions requires increasing levels of learning, particularly reading.[7] Therefore, learning problems are a public health issue of widening significance.[8] They can decrease the quality of life for the affected individual, delay academic achievement, and reduce employment and earnings opportunities.[9,10] Self-esteem and peer relationships can be negatively influenced.[11,12] There is also the possibility of lasting effects on family function, with stresses placed on the community and family for financial and service resources.[13]

Undetected and untreated vision problems are of great concern because they can interfere with the ability to perform to one's full learning potential.[6] When these vision problems have an adverse effect on learning, they are referred to as learning related vision problems.

2. Definition

Learning related vision problems represent deficits in two broad visual system components: visual efficiency and visual information processing.[14] Visual efficiency comprises the basic visual neurophysiological processes of visual acuity (and refractive error), accommodation, vergence, and ocular motility. Visual information processing involves higher brain functions including the non-motor aspects of visual perception and cognition, and their integration with motor, auditory, language, and attention systems.

3. Problems Encountered

Many different forms of learning problems are encountered in optometric practice; the most severe involve learning disabilities. In 1975 the Education for All Handicapped

Children Act, Public Law 94-142, defined learning disability as a disorder in one or more of the basic psychological processes involved in understanding or in using spoken or written language, which may manifest itself in an imperfect ability to listen, think, speak, read, write, spell, or do mathematical calculations. This basic definition has been incorporated into the Individuals with Disabilities Education Act (IDEA), Public Law 101-476.

Learning disabilities are a heterogeneous group of disorders that result in significant difficulties in academic achievement. Learning problems in spoken language can be represented as delays, disorders, or discrepancies in listening and speaking (vocabulary/articulation); in written language, as difficulties with reading, writing, or spelling; in mathematics, as difficulties in performing math functions or comprehending basic concepts; and in reasoning, as difficulties in organizing and integrating thoughts and turning them into effective actions.15 Attention deficits with hyperactivity disorder (ADHD) or without it (ADD) frequently are comorbid with learning disabilities.16-18 Other associated traits, such as impulsiveness, low frustration tolerance, and difficulties with social interactions and situations, are also common.19,20

There is no singular clinical profile of an individual with learning disabilities. The definition of learning disabilities does not identify or describe a specific individual with a specific problem. Nor is there a unitary deficit that accounts for all of the expressions of the disorder, despite many attempts to identify one.

Many individuals have mild or circumscribed learning problems that are not of sufficient magnitude to be classified formally as learning disabilities; nevertheless, they may have significant learning related vision problems.

Learning related vision problems are the manifestation of deficits in visual efficiency and visual information processing. Visual efficiency problems include uncorrected refractive error, dysfunction of accommodation, dysfunction of vergence control systems, and the interaction of these systems and ocular motility. Accommodative and vergence dysfunctions can be primary deficits or can occur secondary to uncorrectrefractive error. Isolated visual efficiency deficits are relatively uncommon; most patients present with multiple deficits. A comprehensive description of accommodative and vergence dysfunctions can be found in the Optometric Clinical Practice Guideline for Care of the Patient with Accommodative and Vergence Dysfunction.21 Visual information processing problems include delays or deficits in visual spatial orientation, visual analysis (which encompasses non-motor visual perception), and visual integration skills.

4. Diagnosis

A learning disability is usually first suspected by a classroom teacher who observes persistent difficulty in some area of academic achievement. Formal diagnosis of learning disabilities is determined locally and usually is made when a significant discrepancy exists between the potential for learning, as defined by a test of intelligence, and actual academic achievement. Diagnostic tests include quantitative achievement tests in academic areas (e.g., reading, spelling), evaluation of expressive and receptive language function, and evaluation of sensory systems.22,23 Vision should be evaluated to rule out potentially consequential deficits.

The definition of learning related vision problems is not universal among educators and other health professionals. Too frequently it is interpreted as visual acuity screening, measured at distance. Although distance visual acuity is relevant for such tasks as copying from the chalkboard, other aspects of vision involving efficiency and information processing are fundamental to such near-point activities as reading, writing, and other classroom and learning activities. Proper diagnosis of learning related vision problems therefore requires comprehensive evaluation of visual efficiency and visual information processing skills.

5. Reading Disabilities and Dyslexia

For the majority of individuals with learning disabilities, reading disability is their primary deficit.[24,25] The role of phonological processing deficits in the understanding of reading disability is significant.[26-29] These deficits are manifested in the failure to use or properly understand phonological information when processing written or oral language. This is seen in the inadequacy of phonemic awareness (synthesis, analysis, segmentation), the poor understanding of sound-symbol (or later grapheme-phoneme) correspondence rules, and the improper storage and retrieval of phonological information. There can also be difficulties with short-term and long-term memory that affect comprehension.

The use of the term "dyslexia" to describe some form of reading disability has been the subject of much discourse.[30] Its application has ranged from the description of reading difficulties only associated with traumatic brain injury to a general synonym for all developmental reading disabilities. It is best understood as a neurocognitive deficit that is specifically related to the reading and spelling processes. There are two situations in which the term dyslexia now commonly applies. The first is when the reader has difficulty decoding words (i.e., single word identification) and encoding words (i.e., spelling).[31,32] The second -- a frequent presentation in optometric practice -- is when the reader makes a significant number of letter reversal errors (e.g., b - d), letter transpositions in words when reading or writing (e.g., sign - sing), or has left-right confusion.[33-36]

6. Visual Efficiency and Learning

Visual efficiency is related to learning, and the avenues for visual efficiency problems to impact learning potential are numerous.[37-39] Eye discomfort may make it difficult to complete school tasks or homework assignments in a timely manner. Distraction or inattention may become secondary complications. Task avoidance is an often overlooked effect. The presence of severe asthenopia during visual tasks can lead to less time on task, decreasing the opportunity for practice and learning, particularly in vocabulary development, comprehension, and reading mechanics. A harmful associative relationship between eye discomfort and the learning activity can develop, leading to disinterest and poor motivation for traditional learning activities.

Blurred, diplopic, or distorted text can be expected to decrease word processing speed and efficiency, reduce reading rate, and compromise reading comprehension. Inadequate attention allocation for information processing can exist when attentional capacity is diverted to manage the visual efficiency problem at the expense of the ongoing processing required for learning. The proliferation of computer-assisted instruction in the school setting -- notwithstanding the dramatic increase in home computer use -- has created an even greater demand for appropriate visual efficiency.

7. Visual Information Processing and Learning

The importance of visual information processing skills for learning is self-evident.[40-42] Visual information processing skills provide the capacity to organize, structure, and interpret visual stimuli, giving meaning to what is seen. Veridical visual information processing leads to perceptual constancy, creating a stable and predictable visual environment. These are important attributes for every learning situation.[40-42] Visual information processing skills considered separately and collectively are related to learning ability and contribute to the total variance in academic achievement.42-54 Individuals with learning problems can present with distinct visual information processing deficits.

B. EPIDEMIOLOGY

Estimates of the prevalence of learning problems among school-aged children range from 2 to 10 percent, depending on the nature of the diagnostic process and the definitions applied by individual school districts.[24,55,56] Nationally,

approximately 5 percent of all school children are diagnosed with learning disabilities; an equal or greater number have milder learning problems. Learning disabilities account for nearly half of all children receiving special educational services. Of that number, as many as 75 percent have particular difficulties with reading. While it was previously thought that males were more affected than females, recent evidence indicates that an equal number of male and females are affected.[57-59] Learning disabilities are both familial and heritable.[60-62]

Appraisals of the prevalence of learning related vision problems vary considerably, depending on the definitions, sample selection criteria, and the examination methods used. At least 20 percent of individuals with learning disabilities have been found to have prominent visual information processing problems.[63-66] The prevalence of visual efficiency problems is thought to be in the 15 to 20 percent range[67-69] Accommodative dysfunctions have been reported to occur in 60 to 80 percent of individuals with vision efficiency problems; accommodative insufficiency is the most prevalent type.[21] Convergence insufficiency is the most common vergence anomaly.[21]

During the child's first years in school, academic instruction places demand on a child's visual information processing skills. There is an emphasis on recognition, matching, and recall. Periods of sustained near work are infrequent, and visual stimuli (i.e., letters) are relatively large and widely spaced. Visual efficiency becomes a more significant need later in the educational process. Reading demands increase with the need to achieve grade-appropriate rates of reading with comprehension and they require effort over more extended periods of time, when letters and text become smaller and more closely spaced. This increase in sustained periods of near work becomes a significant risk factor for the development of visual efficiency problems.

C. COURSE AND PROGNOSIS

Although some behaviors commonly associated with learning problems may occur before a child enters school, formal diagnosis of learning disabilities does not begin until the end of kindergarten or during first grade, because formal academic instruction begins at that time. During the preschool years, failure to achieve developmental milestones may be the first indication of risk for the appearance of learning disabilities. Delays in gross and fine motor development, receptive and/or expressive language, particularly phonological processing, and visual information processing may be the antecedents to learning problems. The purpose of early screening and intervention programs is to identify children with developmental delays who may be at significant risk for learning problems.

With early diagnosis and appropriate, comprehensive intervention, the prognosis is good in a majority of cases. Symptoms of learning disabilities frequently persist into adult life and rarely disappear entirely.[70-72]

The clinical presentation of persistent visual efficiency problems may change during periods of remission and exacerbation, depending on prevailing intrinsic and extrinsic influences.

Visual information processing deficits are usually considered developmental in nature. With maturation and experience there will be increases in performance, but the rate of progression of skill development continues to lag.

D. EARLY DETECTION

Because the evidence that learning related vision problems can be prevented to any substantial degree is inconclusive, the emphasis is on early detection. It is recommended that vision examinations be scheduled at 6 months, 3 years of age, and at entry into school,[73] at which time the parents should complete a developmental questionnaire. If there is a history of developmental delay, a screening test like the Denver Developmental Screening Test can be performed. When visual information processing problems are suspected, a more

extensive evaluation is necessary for the early identification of the child at risk for the development of learning related vision problems.

Most school districts now conduct some form of developmental screening before children enter school. Such screenings tend not to explore visual information processing development as extensively as needed. The majority of school vision screenings test only distance visual acuity and are woefully inadequate in detecting most learning related vision problems. Thorough eye and vision examinations during the preschool years and consistently through the school years continue to be the most effective approach to early detection of visual efficiency and information processing problems.

II. CARE PROCESS

A. GENERAL CONSIDERATIONS

Care of the patient with learning related vision problems involves taking a patient history and examining visual efficiency, visual information processing ability, and visual pathway integrity. The Optometric Clinical Practice Guideline for the Pediatric Eye and Vision Examination should be consulted for additional information.[73]

B. PATIENT HISTORY

The patient history is the initial component of the care process and an important part of an appropriate diagnosis.[74] Collection of demographic data usually precedes and supplements the history taking. A questionnaire completed by the parent or caregiver can facilitate the history process. Special attention should be directed to developmental milestones and academic performance. Questions should be constructed to define the specific nature of the learning and vision problems and should be used as a guide for the subsequent testing sequence. Information obtained directly from teachers or therapists can be helpful.

Language delays are common in individuals with learning problems. As a result, sufficiently detailed descriptions of learning or visual symptoms obtained directly from the patient may be lacking. This could result in an underestimation of the severity of the symptoms and should not be the exclusive source of such information.

A comprehensive patient history for learning related vision problems may include:

- Chief concern or complaint
- History of present illness

  - Patient visual history
  - Patient ocular history
- Patient medical history
  - Exploration of risk factors: perinatal events, childhood illnesses
- Developmental history
  - Gross motor
  - Fine motor
  - Language
  - Personal/social milestones
- Family history
  - Visual/ocular
  - Medical
  - Academic/educational
- Academic/educational history
  - Previous assessments and interventions
  - Current assessment, interventions, and placement
    - Occupational/physical therapy
    - Speech and language
    - Learning disability

Psychoeducational

Remedial reading

Behavioral

Current achievement levels

Reading

Spelling

Mathematics

Writing

Academic/education-related medical history

Pediatric

Neurological

Audiological

Medications

C. VISUAL EFFICIENCY EVALUATION

Visual efficiency problems are related to learning achievement. An analysis of the literature on the subject indicatesthat refractive error -- in particular hyperopia and significant anisometropia, accommodative and vergence dysfunctions, and eye movement disorders -- are associated with learning problems.[75-85] Therefore, a thorough clinical investigation for the presence of these conditions in the individual with learning problems is important.

Though they are extremely important functional vision disorders to diagnose and treat early, other binocular vision disor

ders such as constant strabismus and amblyopia have not been found to be associated with learning problems.

Some patients with visual information processing deficiencies, particularly deficiencies of discrimination and memory, may have difficulty making reliable responses during subjective testing. The clinician may have to make necessary compensations or use alternative testing procedures to obtain relevant information. Reliance on objective findings for clinical decisionmaking may be necessary.

1. Visual Acuity

Assessment of visual acuity in patients with learning related vision problems should be measured monocularly and binocularly at distance and near point. Patients with sufficient verbal communication who know the alphabet can be tested using a Snellen chart. If difficulties are encountered, an assessment of visual acuity may include the following methods:

- HOTV
- Broken Wheel
- Tumbling E.

The Optometric Clinical Practice Guideline for the Pediatric Eye and Vision Examination should be consulted for additional information.73

2. Refraction

The measurement of refractive error should include:

- Static retinoscopy
- Subjective refraction.

Because of the importance of detecting hyperopia -- particularly latent hyperopia -- proper fogging technique should be maintained during retinoscopy and subjective refraction. A cycloplegic refraction may be indicated if latent hyperopia or pseudomyopia is suspected, or if convergence excess or accommodative insufficiency is diagnosed.

3. Ocular Motility and Alignment

Deficiencies in ocular motility have been associated with learning problems.[86-92] Ocular motility is typically evaluated by chairside tests of fixation stability, and of saccadic and smooth pursuit eye movements.[86,87] In addition to investigation of basic neurological and extraocular muscle function in patients with learning related vision problems, qualitative analysis of their ocular motility is necessary. Although almost all learning tasks require sequences of fixation-saccade-fixation, there are two reasons for also testing pursuit eye movements: (1) Pursuits are vital for locomotion, sports-related activities, and general spatial orientation. (2) An important part of the neurological control process for smooth pursuit eye movement, the magnocellular pathway, is deficient in individuals with reading disabilities.[93-99]

The following standardized observational rating systems have been developed:

- NSUCO100 (Northeastern State University College of Optometry)
- SCCO 4+101 (Southern California College of Optometry)

For smooth pursuit testing, both of these systems involve tracking a target moving in a circle. Evaluation of performance is by gain (eye velocity in relation to target velocity) and the number of catch-up saccades to reacquire the target.

Both systems investigate predictive saccades between two fixed targets positioned centrally, equidistant from the midline. Hypometric inaccuracies are commonly found in individuals with poor saccadic eye movement control. Ocular motility deficiencies are frequently accompanied by excessive head and body movements (motor overflow). The clinical signs and symptoms of ocular motility deficiencies can be found in Table 1.

Table 1
Signs and Symptoms of Ocular Motility Dysfunction

- Moving head excessively when reading
- Skipping lines when reading
- Omitting words and transposing words when reading
- Losing place when reading
- Requiring finger or marker to keep place when reading
- Experiencing confusion during the return sweep phase of reading
- Experiencing illusory text movement
- Having deficient ball-playing skills

Assessment tools are available for a more quantitative evaluation, albeit indirect, of saccadic eye movements. These tests simulate reading, using a rapid number-naming strategy in which numbers are placed in horizontal spatial arrays to be read in the left-to-right and top-down fashion of normal reading. The time to complete the task and the number of errors are the clinical outcomes. Presumably, slower and/or error-prone performance would indicate poor saccadic eye movement control. The following available tests, which are norm-referenced for the patient's age and grade in school, clearly indicate the developmental course of skill improvement:

- Developmental Eye Movement Test (DEM)102
- King-Devick Saccade Test (K-D).103

Unfortunately, naming the tasks confounds the results because both eye movement skill and naming speed are required to complete the test successfully. However, because the DEM incorporates a subtest of naming speed that isolates eye movement skill for a more specific clinical diagnosis, it's use is preferred.

Infrared eye-monitoring systems that directly measure eye movements during reading (e.g., Visagraph II) are also available. Although they do not measure saccade dynamics (accuracy, latency) or main sequence, these assessment tools can provide data on the number of fixations required to read a sample of text, as well as the number of regressions and the reading rate.

Eye alignment is usually determined by a distance and near cover test. If a strabismus is found, the Optometric Clinical Practice Guideline for the Care of the Patient with Strabismus: Esotropia and Exotropia should be consulted for additional information.104

4. Accommodative-Vergence Function

Evaluation of accommodation and vergence amplitude, facility, accuracy, consistency, and sustainability is required and may include the following procedures or measurements:

- Cover test
- Near point of convergence
- Heterophoria, distance and near
- Fusional vergence amplitudes, distance and near
- Vergence facility
- Amplitude of accommodation
- Accuracy of accommodation (lag)
- Relative accommodation
- Accommodative facility
- Fixation disparity analysis
- Stereopsis

The evaluation of accommodation and vergence should include assessment of both the range and facility of response. The ability to make rapid changes in accommodative and vergence response is important for school-related tasks

(e.g., copying from the chalkboard or taking notes). Facility testing also probes sustainability of the response, which is important for extended near-point activities (e.g., reading). The clinical signs and symptoms of accommodative and vergence dysfunctions can be found in Table 2.105 The Optometric Clinical Practice Guideline for Care of the Patient with Accommodative and Vergence Dysfunction provides for more detailed assessment information.[21]

Table 2
Signs and Symptoms of Accommodative Vergence Dysfunctions

- Asthenopia when reading or writing
- Headaches associated with near visual tasks
- Blurred vision at distance or near
- Diplopia
- Decreased attention for near visual tasks
- Close near working distance
- Overlapping letters/words in reading
- Burning sensations or tearing of the eyes during near visual tasks

5. Physical Diagnosis

The assessment of visual system integrity should include:

- Evaluation of the anterior segment
- Evaluation of the posterior segment
- Color vision testing
- Assessment of pupillary responses
- Visual field screening.

Standard testing procedures for the evaluation of visual system integrity can be used in patients with learning related vision problems. For additional information consult the Optometric Clinical Practice Guideline for the Pediatric Eye and Vision Examination.[73]

D. VISUAL INFORMATION PROCESSING EVALUATION

1. General Considerations

The visual information processing skills that require testing are visual spatial orientation skills, visual analysis skills, including auditory-visual integration, visual-motor integration skills,106 and visual-verbal integration skills.[106,107] When available, norm-referenced tests are preferred for this purpose.108 Testing should be conducted uniformly and according to the exact methods specified in the test instructions. Specified rule-based scoring procedures should be followed. Qualitative insights from observation of the test taker's behavior can provide important supplementary information for diagnosis and management. Attention to task, ability to understand the instructional set, cognitive style, problem-solving ability, frustration tolerance, and excessive motor activity are some of the behaviors worth observing.

Testing should be done without interruption in a relatively quiet environment. Individuals with attention deficits may require rest periods between tests or multiple testing sessions. For a comprehensive visual information processing evaluation, one or two tests from each category can be selected for administration. For a detailed or problem-focused evaluation of a specific visual information processing skill, multiple tests from the same category can be administered.

2. Visual Spatial Orientation Skills

Visual spatial orientation is the awareness of one's own position in space relative to other objects, as well as the location of objects relative to each other. It includes body knowledge and control, as well as bimanual integration. Visual spatial orientation skills involve the ability to understand directional concepts, both internally and projected into external visual space. These skills are important for balance and coordinated body movements, navigation in the environment, following spatial directions, and understanding the orientation of alphanumeric symbols. The clinical signs and symptoms of visual spatial

orientation skill deficiencies can be found in Table 3.

Table 3
Signs and Symptoms of Visual Spatial Orientation Skill Deficiency

- Delayed development of gross motor skills
- Decreased coordination, balance, and ball-playing skills
- Confusion of right and left
- Letter reversal errors when writing or reading
- Inconsistent directional attack when reading
- Inconsistent dominant handedness
- Difficulty in tasks requiring crossing of the midline

Visual spatial orientation skills are frequently subdivided into bilateral integration, laterality, and directionality. Bilateral integration is the awareness and use of the extremities, both separately and simultaneously in unilateral and bilateral combinations. Laterality is the internal representation and sensory awareness of both sides of one's own body. Directionality is the ability to understand and identify right and left directions in external visual space, including orientational specificity of written language symbols.

Visual spatial orientation skills can be evaluated by several categories of tests.

a. Bilateral Integration

- Body Knowledge and Control - Standing Test
- Chalkboard Circles Test.

Body knowledge and control requires the conversion of a tactile stimulus into a motor response -- i.e., moving the extremities in response to touch -- while standing. The chalkboard circles test requires the simultaneous production of large circles with both hands symmetrically and reciprocally on a large chalkboard, with the eyes fixating straight ahead. Each of these two criterion referenced tests is scored by observing performance and comparing it to an age-related criterion.

b. Laterality and Directionality

- Piaget Right-Left Awareness Test
- Reversals Frequency Test
- Jordan Left-Right Reversal Test – Revised.

The criterion-referenced Piaget Right-Left Awareness test requires a response to verbal instruction to move a named extremity and to place objects to the right or left of another object. The Reversals Frequency and Jordan tests are both norm-referenced and require the recognition of correctly oriented letters and numbers. The Reversals Frequency test has an execution subtest that evaluates the frequency of reversal errors that occur when writing letters and numbers from dictation.

3. Visual Analysis Skills

Commonly referred to as "visual perception," visual analysis skills are the active processes for locating, selecting, extracting, analyzing, recalling, and manipulating relevant information in the visual environment. These processes represent one of the core skills for letter and number recognition, sight word vocabulary, and mathematical concepts. Visual analysis skills have traditionally been subdivided into separate theoretical constructs: visual discrimination, visual figure-ground perception, visual closure, visual memory, and visualization.

a. Visual Discrimination

Visual discrimination is the awareness of distinctive features of objects and written language symbols, including shape, orientation, and size. Visual figure-ground perception is the ability to select and process an object or a specific feature of an object from a background of competing stimuli. Visual closure is the capacity to identify an object accurately when the details and features available for analysis and processing are

incomplete. Visual memory is the ability to recognize or recall previously presented visual stimuli, whether individual or grouped in a specific sequence. The clinical signs and symptoms of visual analysis skill deficiencies can be found in Table 4.

Table 4
Signs and Symptoms of Visual Analysis Skill Deficiency

- Delayed learning of the alphabet (letter identification)
- Poor automatic recognition of words (sight word vocabulary)
- Difficulty performing basic mathematics operations
- Confusion between similar-looking words (apparent letter transpositions)
- Difficulty spelling nonregular words
- Difficulty with classification of objects on the basis of their visual attributes (e.g., shape, size)
- Decreased automatic recognition of likenesses and differences in visual stimuli

Visual discrimination tests involve a match-to-sample paradigm, in which the match may involve variations in stimulus size or orientation. Visual discrimination can be tested with the following:

- Visual Discrimination subtest of the Test of Visual Perceptual Skills - Revised
- Form Constancy subtest of the Test of Visual Perceptual Skills - Revised
- Form Constancy subtest of the Developmental Test of Visual Perception - 2
- Matching Familiar Figures Test
- Visual Discrimination subtest of the Motor Free Vision Perception Test.

b. Visual Figure-Ground

These tests involve a match-to-sample paradigm, requiring detection of the test stimulus embedded in a confusing background or among other superimposed stimuli. Visual figure-ground can be tested with the following:

- Visual Figure-Ground subtest of the Test of Visual Perceptual Skills - Revised
- Figure-Ground subtest of the Developmental Test of Visual Perception - 2
- Figure-Ground subtest of the Motor Free Vision Perception Test
- Figure-Ground Perception subtest of the Southern California Sensory Integration Test.

c. *Visual Closure*

These tests involve a match-to-sample paradigm, requiring the identification of the target stimulus among incomplete forms. Visual closure can be tested with the following:

- Visual Closure subtest of the Test of Visual Perceptual Skills - Revised
- Visual Closure subtest of the Developmental Test of Visual Perception - 2
- Picture Fragments subtest of the Detroit Test of Learning Aptitude - 3
- Gestalt Closure subtest of the Kaufman - Assessment Battery for Children
- Visual Closure subtest of the Motor Free Vision Perception Test.

d. *Visual Memory and Visualization*

Two aspects of visual memory are considered: visual sequential memory and visual spatial memory. Visual sequential memory requires the recall of an exact sequence of letters, numbers, symbols, or objects. Visual spatial memory requires recall of the spatial location of a previously seen stimulus and the ability to identify or reproduce it. Visualization requires the ability to manipulate visual images mentally.

Visual memory can be tested with the following:

- Visual Memory subtest of the Test of Visual Perceptual Skills - Revised

- Visual Sequential Memory subtest of the Test of Visual Perceptual Skills - Revised
- Spatial Memory subtest of the Kaufman - Assessment Battery for Children
- Letter Sequences subtest of the Detroit Test of Learning Aptitude - 2
- Design Sequences subtest of the Detroit Test of Learning Aptitude - 4
- Visual Memory subtest of the Motor Free Vision Perception Test.

Visualization can be tested with the:

- Spatial Relations Test of the Primary Mental Abilities.

The Spatial Relations test requires that a geometric segment of a square be chosen from several possible responses to complete the square correctly. The correct response is never presented in the proper orientation, so that completion of the square requires mental rotation of the image.

e. *Composite Visual Perception Assessment*

The revised version of the Motor Free Visual Perception test has been designed to provide a general, overall non-motor visual perception score encompassing visual discrimination, figure-ground, closure, and memory rather than separate categorical scores.

f. *Visual-Motor Integration*

Visual-motor integration (or visually guided motor response) is the ability to integrate visual information processing with fine motor movements and to translate abstract visual information into an equivalent fine motor activity, typically the fine motor activity of the hand in copying and writing. Visual-motor integration involves three individual processes: visual analysis of the stimulus, fine-motor control (or eye-hand coordination), and visual conceptualization, which includes the integration process itself. Deficits in any one of these processes will influence the overall result. deficient, the difficulties lie in the integration-processing phase. The clinical signs and symptoms of visual-motor integration skill deficiency can be found in Table 5.

Table 5
Signs and Symptoms of Visual-Motor Skill Deficiency

- Difficulty copying from the chalkboard
- Writing delays, mistakes, confusions
- Letter reversals or transpositions when writing
- Poor spacing and organization of written work
- Misalignment of vertical numbers in columns when doing math problems
- Poorer written spelling than oral spelling
- Poor posture when writing, with or without torticollis
- Exaggerated paper rotation(s) when writing
- Awkward pencil grip

Visual-motor integration tests usually require the subject to copy progressively complex geometric forms. The Wold Sentence Copy test is an exception in that it tests speed and accuracy in copying a sentence, an activity comparable to desktop copying tasks in the classroom. Visual-motor integration can be tested with the following:

- Beery-Buktenica Developmental Test of Visual Motor Integration - 4
- Test of Visual-Motor Skills - Revised
- Wide Range Assessment of Visual Motor Abilities
- Copying Subtest of the Developmental Test of Visual Perception - 2
- Test of Visual Analysis Skills
- Wold Sentence Copy Test.

g. Eye-Hand Coordination

The following instruments can test eye-hand coordination:

- Grooved Pegboard Test
- Eye-Hand Coordination subtest of the Developmental Test of Vision Perception –2

The Grooved Pegboard test involves the integration of tactile, visual, and fine motor skills requiring manipulative dexterity. The task is to insert slotted pegs into a pegboard with holes that have randomly rotated slots. This timed test differentiates accuracy from automatic processing. The Eye-Hand Coordination subtest requires the accurate drawing of lines within narrow channels, both straight and curved.

h. Auditory-Visual Integration

The ability to match a chain of auditory stimuli (usually sounds) to a correct visual representation of that stimulus chain, auditory-visual integration, requires remembering the sequence and spacing of sounds and then integrating that information with the visual modality. An auditory-visual integration task can also be viewed as a temporal-to-spatial association or integration task. Auditory-visual integration is an important skill for establishing the proper association of sounds with visual symbols, as required for learning letters and words. Table 6 presents the clinical signs and symptoms of auditory-visual integration deficiency.

Table 6
Signs and Symptoms of Auditory Visual Integration Deficiencies

- Difficulty with sound-symbol associations
- Difficulty with spelling
- Slow reading

Auditory-visual integration can be tested with the:

- Auditory-Visual Integration Test.

The Auditory-Visual Integration test requires that the examiner tap out a series of sounds with time delays placed between sound clusters. The subject's task is to select the proper visual representation (dots) of the sequence of sounds and delays from choices printed on cards.

4. Visual-Verbal Integration

Visual-verbal integration, which involves the rapid retrieval of a verbal label for a visually presented stimulus,[109] is dependent on rapid visual processing of the stimulus. Visual-verbal integration skills are required for efficient reading and have a particular effect on the speed of word identification. The visual and expressive language processes required for rapid naming of objects or alphanumeric characters are quite similar to those required for the identification and recognition of single words. Slow naming may be a reflection of the phonological processing deficiencies common among individuals who have learning problems or a deficit in another cognitive process.[109-115] Rapid "automatized" naming has predictive power for later word identification ability but not for reading comprehension.[114]

Testing of visual-verbal integration usually requires the rapid naming of arrays of visually presented objects or numbers. The clinical signs and symptoms of visual-verbal integration skill deficiency can be found in Table 7.

Visual-verbal integration can be tested with the following:

- Vertical subtest of the Developmental Eye Movement Test[102]
- Rapid Automatized Naming Test[112]
- Boston Naming Test.[116]

Table 7
Signs and Symptoms of Visual-Verbal Integration Deficiencies

- Difficulty learning the alphabet (letter identification)
- Difficulty with spelling
- Faulty sight word vocabulary (word recognition)
- Slow reading

The vertical subtest of the Developmental Eye Movement test (DEM) requires the rapid naming of numbers presented in four vertical columns of 20 numbers each. The Rapid Automatized Naming test requires naming as rapidly as possible the items presented on a chart (colors, lower-case letters, numbers, common objects). Each chart contains five rows of 10 stimuli.

The Boston Naming test is a confrontation-naming task in which line drawings of familiar objects are to be named. It is not an automatized task, but it allows for an indication of knowledge of the items presented.

E. SUPPLEMENTAL TESTING

1. Reading and Spelling

There have been many attempts to subtype learning (reading) problems into distinct groups of individuals, by identifying similarities in their performance profiles. This reasoning is related to neurocognitive models that assume that significant differences in auditory- and visual-processing abilities account for different forms of learning problems. One popular approach is the achievement classification model based on performance in word recognition and spelling tasks. Standardized tests that are available to measure these parameters include:

- Boder Test of Reading-Spelling Patterns[64]
- Dyslexia Determination Test.[117]

Both tests identify the reading problem from the results of a reading recognition task involving graded word lists of regular and nonregular words. A reading grade level is obtained from this task. On the basis of this reading performance, an individualized list of spelling words is selected from the sight-word vocabulary and other words. Analysis of the types of spelling errors made is used to subtype the reading problem into dyseidetic, dysphonetic, or mixed type. Patients of the dyseidetic subtype are characterized by visual information processing deficits, including visual memory and visualization.

These individuals have limited sight word vocabularies and they over-rely on phonetic decoding strategies that interfere with efficient reading. Those of the dysphonetic subtype are characterized by poor understanding and application of phonetic decoding rules. Their visual information processing capacity is relatively strong. However, it is important to note that this reading disability subtype has been associated with magnocellular visual pathway deficits.[118]

2. Magnocellular Pathway

Research has shown that a deficient magnocellular pathway is associated with reading disabilities. Several convergent lines of psychophysical,[93-97] electrophysiological,[98-99] and anatomical99 evidence support this conclusion. Compared with normal readers, the population of disabled readers has prolonged visual persistence in response to stimuli of low spatial frequency, lower contrast sensitivity at low spatial frequencies, reduced flicker sensitivity, poorer temporal resolution and integration, anomalous time course and strength of metacontrast masking functions, and reduced effects of flicker masking. More recently, research has shown that disabled readers demonstrate reduced magnetic resonance imaging (MRI) responses to moving stimuli,[119-121] have less subjective sensitivity to the detection of motion,122 and have abnormalities in reflexive, stimulus-induced visual attention.[123]

A magnocellular pathway deficit could produce the perception of overlapping text or illusory text movement, disrupting the proper timing and accuracy of saccadic eye movements, the proper spatial and temporal disposition of visual attention, and the temporal order of visual processing of words. At present no standard clinical tests are readily available to clinicians for the evaluation of magnocellular function. The most promising tests are visual evoked potentials using low-contrast and low-spatial frequency stimuli, and motion detection paradigms.

F. ASSESSMENT AND DIAGNOSIS

All data obtained from testing should be evaluated to establish

one or more clinical diagnoses and develop a management plan. Examination of the patient history, clinical signs and symptoms, test results and behavioral observations, and review of previous reports and present levels of care are necessary to accomplish this. Low test scores should be referenced to the expected signs and symptoms of that deficiency.

In the analysis of the visual efficiency performance data obtained, it is necessary to examine all of the data collectively by a standard clinical protocol, rather than relying on a singular finding to arrive at a diagnosis. The Optometric Clinical Practice Guideline for Care of the Patient with Accommodative and Vergence Dysfunction provides lists and descriptions of common accommodative and vergence dysfunctions and methods of data analysis.[21]

For testing visual information processing the use of z (or standard) scores is recommended. The z score is the deviation of a specific test score from the mean, expressed in standard deviation units. It allows the expression of any score as a percentile rank by comparing it to a standard normal distribution. A test result with a z score that is ≥1.5 standard deviations below the mean (percentile rank = 6.68) should definitely be considered anomalous and clinically significant.[124] Scores falling between 1.0 and 1.5 standard deviations below the mean should be considered suspicious and perhaps clinically relevant, depending on the overall clinical picture, the nature and type of the learning problem, and the level of overall cognitive function.

Parents and school systems often prefer the expression of performance as an age or grade equivalent, or as a percentile rank, to enable direct comparison with expected performance levels. It is important to relate visual information processing test results to the current level of cognitive function as measured by IQ tests such as the Weschler Intelligence Scale for Children - Revised (WISC - R). In the case of individuals with low average IQ scores, overall performance in visual information processing in the same range may not be indicative of a problem, but rather the expected level of performance.

G. MANAGEMENT

The goal of the management of learning related vision problems is to prepare the individual to take full advantage of the opportunities for learning. Optometric intervention directed toward improving visual function to its appropriate level[125] has been shown to be efficacious.[21,82,126-133] It does not replace conventional educational programming but is a necessary complementary intervention to maximize the learning environment and the effectiveness of pedagogy. In most situations, optometric intervention for learning related vision problems is delivered in conjunction with other professionals involved in the management of the learning problem from an educational or medical perspective. Interdisciplinary communication, consultation, and referral are vital for the most effective management of the individual with learning problems.

The management of learning related vision problems should be directed at the identification and treatment of specific visual deficits. The expectation for intervention should be the reduction or elimination of the signs and symptoms associated with particular visual deficits. The goals of optometric intervention should be specific and problem oriented, rather than indefinite such as "to improve school performance." To the extent that visual deficits influence school performance, improvement can result from optometric intervention.

Learning related vision problems are usually managed in a progressive sequence. Treatment should begin with consideration of refractive status. Careful attention should be paid to the correction of hyperopia and anisometropia because of their known association with learning problems. Sometimes even slight degrees of hyperopia or anisometropia can be problematic.

Next, visual efficiency deficits should be treated aggressively,

using lenses, prisms, and vision therapy. The Optometric Clinical Practice Guideline for Care of the Patient with Accommodative and Vergence Dysfunction offers more detailed management recommendations.[21] The specific goal for the treatment of visual efficiency deficits is enhancement of the range, latency, accuracy, facility, and sustainability of accommodative and vergence responses. At the conclusion of therapy, ocular motility should be more accurate, and the incidence of accompanying head and body movement lower.

Correction of refractive error and treatment of visual efficiency dysfunctions can result in improved visual information processing.82 Nevertheless, the treatment of vision information processing deficits usually requires vision therapy, which can begin during the later stages of visual efficiency therapy. When deficits in visual efficiency are minor, information processing therapy can be initiated at the outset. The approach is typically hierarchical, beginning with visual spatial orientation, then continuing with visual analysis and concluding with visual-motor integration. Attention should be directed toward improving the rate of visual information processing. The goals of visual information processing therapy can be found in Table 8. Developing intrinsic motivation so that the patient becomes aware of increasing mastery of the skill being acquired is an important part of the therapy program.[134]

Table 8
Goals for Vision Information Processing Therapy

- Develop motor planning ability to accomplish isolated and simultaneous movements of the extremities
- Develop motor memory of the differences between the right and left sides of the body
- Develop an internal awareness of both sides of the body, including identification of body parts
- Develop the ability to project directional concepts to organize visual space, including the spatial orientation of alphanumeric symbols
- Develop an understanding of the distinctive features of objects; namely size, shape, color, and orientation
- Develop the ability to select and attend to a stimulus from an array of distracting stimuli, as well as the spatial relationship of that stimulus relative to other background stimuli
- Develop the ability for identification of visual stimuli from incomplete information
- Develop short-term visual memory abilities, including the recall of the spatial characteristics of the stimulus and the sequence of multiple stimuli
- Develop the ability to develop a visual image of a previously presented stimulus and the capacity to mentally manipulate it
- Develop the ability to integrate visual processing skills with the fine-motor system to reproduce complex visual stimuli
- Develop the ability to integrate visual processing skills with the language system efficiently and rapidly

Vision therapy is usually conducted in the optometrist's office and home support activities are prescribed. One or two office visits per week for 12 to 24 weeks may be required for uncomplicated cases. Office therapy sessions usually begin with review of the activities assigned for practice at home. This review should include a demonstration of the procedures and an indication of the level of compliance.

Supportive activities performed at home 4 to 5 days per week for 20 to 30 minutes each time are an important adjunct to office-based therapy, providing continuity of care and enhancing opportunities for practice and mastery of skills. Consistent application of supportive activities at home may reduce the number of office visits required and the potential for regression.

Many vision therapy techniques and procedures available to address visual information processing problems135 are described in several recommended compilations.[125,136-141] Several of these are computer vision therapy programs.

After this initial period of therapy, a re-evaluation should be performed, using the same visual information processing tests employed previously, and an exploration of improvements in clinical signs and symptoms made. An improvement in test performance of at least 1.5 standard errors of measurement is considered clinically significant.[124] Additional therapy may be indicated if clinical signs and symptoms -- although improved -- persist to some degree. When the patient has made sufficient progress, and has achieved the major therapeutic goals for visual information processing skill enhancement and reduction in clinical signs and symptoms, a home-based maintenance program should be recommended. This maintenance program can include practicing a few procedures 2 to 3 times per week for 10 to 15 minutes each time for 3 months.When underlying neurological problems, cognitive deficits, or emotional disorders are suspected, referral to another health care professional or the educational system may be indicated.

Occupational or physical therapy can complement optometric vision therapy when the deficiencies are severe.

H. PARENT AND PATIENT EDUCATION

Specific communication with the patient’s parents or caregivers should occur after the examination to review the test outcomes. This discussion should begin with a review of the chief complaint. An explanation of the nature of the vision problem and its relationship to the presenting signs and symptoms is necessary. The management plan and prognosis should be presented to the patient and parents or caregivers. Communication with education professionals about the diagnosis, proposed management plan, and expected outcomes should be initiated. This should lead to a coordinated effort with the patient’s classroom teachers, special education teachers, and therapists. The importance of continuing eye care should be discussed with parents or caregivers. Other education and health care professionals should be informed about the presence and nature of the learning related vision problems and their relationship to extant learning difficulties.

CONCLUSION

Learning related vision problems comprise deficits in visual efficiency and visual information processing that have potential to interfere with the ability to perform to one's full learning potential. These deficits may cause clinical signs and symptoms that range from asthenopia and blurred vision to delayed learning of the alphabet, difficulty with reading and spelling, and skipping words and losing place when reading.

Vision related learning problems have a relatively high prevalence in the population. They respond favorably to the appropriate use of lenses, prisms, and vision therapy, either alone or in combination. Vision therapy is usually conducted in-office, and home support activities are prescribed. The goal of optometric intervention is to improve visual function to the appropriate level.

The diagnosis of a learning related vision problem must be accurate and thorough. It is likewise essential that the optometrist discuss the diagnosis with the parents or caregivers, and the patient, communicate with other professionals as required, and develop a management plan. Optometric intervention should be coordinated with other education and health professionals’ management of the associated learning problem, to ensure the maximum opportunity for improvement.

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IV. APPENDIX

Figure 1
Vision, Learning and Dyslexia
A Joint Organizational Policy Statement

American Academy of Optometry
American Optometric Association

VISION AND LEARNING

Many children and adults continue to struggle with learning in the classroom and the workplace. Advances in information technology, its expanding necessity, and its accessibility are placing greater demands on people for efficient learning and information processing.[1,2]

Learning is accomplished through complex and interrelated processes, one of which is vision. Determining the relationships between vision and learning involves more than evaluating eye health and visual acuity (clarity of sight). Problems in identifying and treating people with learning-related vision problems arise when such a limited definition of vision is employed.[3]

This position statement addresses these issues, which are important to individuals who have learning-related vision problems, their families, their teachers, the educational system, and society.

POLICY STATEMENT

People at risk for learning-related vision problems should receive a comprehensive optometric evaluation. This evaluation should be conducted as part of a multidisciplinary approach in which all appropriate areas of function are evaluated and managed.[4]

The role of the optometrist when evaluating people for learning-related vision problems is to conduct a thorough assessment of eye health and visual functions and communicate the results and recommendations.[5] The management plan may

include treatment, guidance and appropriate referral.

The expected outcome of optometric intervention is an improvement in visual function with the alleviation of associated signs and symptoms. Optometric intervention for people with learning-related vision problems consists of lenses, prisms, and vision therapy. Vision therapy does not directly treat learning disabilities or dyslexia.[6,7] Vision therapy is a treatment to improve visual efficiency and visual processing, thereby allowing the person to be more responsive to educational instruction.[4,8] It does not preclude any other form of treatment and should be part of a multidisciplinary approach to learning disabilities.[6,7]

PERTINENT ISSUES

Vision is a fundamental factor in the learning process. The three interrelated areas of visual function are:

1. Visual pathway integrity including eye health, visual acuity, and refractive status;
2. Visual efficiency including accommodation (focusing), binocular vision (eye teaming), and eye movements;
3. Visual information processing including identification and discrimination, spatial awareness, memory, and integration with other senses.

To identify learning-related vision problems, each of these interrelated areas must be fully evaluated.

Educational, neuropsychological, and medical research has suggested distinct subtypes of learning difficulties.[9,10] Current research indicates that some people with reading difficulties have co-existing visual and language processing deficits.11 For this reason, no single treatment, profession, or discipline can be expected to adequately address all of their needs.

Unresolved visual deficits can impair the ability to respond fully to educational instruction.[12,13] Management may require optical correction, vision therapy, or a combination of both. Vision therapy, the art and science of developing and enhancing visual abilities and remediating vision dysfunctions, has a firm foundation in vision science, and both its application and efficacy have been established in the scientific literature.[14-17] Some sources have erroneously associated optometric vision therapy with controversial and unfounded therapies, and equate eye defects with visual dysfunctions.[18-21]

The eyes, visual pathways, and brain comprise the visual system. Therefore, to understand the complexities of visual function, one must look at the total visual system. Recent research has demonstrated that some people with reading disabilities have deficits in the transmission of information to the brain through a defective visual pathway.[22-25] This creates confusion and disrupts the normal visual timing functions in reading.

Visual defects, such as a restriction in the visual field, can have a substantial impact on reading performance.[26] Eye strain and double vision resulting from convergence insufficiency can also be a significant handicap to learning.[27] There are more subtle visual defects that influence learning, affecting different people to different degrees. Vision is a multifaceted process and its relationships to reading and learning are complex.[28-29] Each area of visual function must be considered in the evaluation of people who are experiencing reading or other learning problems. Likewise, treatment programs for learning-related vision problems must be designed individually to meet each person's unique needs.

SUMMARY

1. Vision problems can and often do interfere with learning.
2. People at risk for learning-related vision problems should be evaluated by an optometrist who provides diagnostic and management services in this area.
3. The goal of optometric intervention is to improve visual function and alleviate associated signs and symptoms.
4. Prompt remediation of learning- related vision problems enhances the ability of children and adults to perform to their full potential.

5. People with learning problems require help from many disciplines to meet the learning challenges they face. Optometric involvement constitutes one aspect of the multidisciplinary management approach required to prepare the individual for lifelong learning.

This Policy Statement was formulated by a Task Force representing the College of Optometrists in Vision Development, the American Optometric Association, and the American Academy of Optometry. The following individuals are acknowledged for their contributions:

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Figure 2

ICD-9-CM CODES

315.00 Specific reading disorder
315.02 Developmental dyslexia

315.2 Other specific learning difficulties

379.57 Deficiencies of saccadic eye movement

379.58 Deficiencies of pursuit eye movements
Other ICD-9-CM codes for accommodative and vergence dysfunctions can be found in the Optometric Clinical Practice Guideline for Care of the Patient with Accommodative and Vergence Dysfunction.21

Abbreviations of Commonly Used Terms

ADD . . . . .Attention deficit without hyperactivity disorder

ADHD . . .Attention deficit with hyperactivity disorder

DEM . . . . .Developmental Eye Movement Test

IDEA . . . .Individuals with Disabilities Education Act

K-D . . . . . .King-Devick Saccade Test

MRI . . . . . .Magnetic resonance imaging

NSUCO . .Northeastern State University College of Optometry

SCCO . . . .Southern California College of Optometry

WISC-R . .Weschler Intelligence Scale for Children - Revised

z score . . . .Standard score

GLOSSARY

Accommodation The ability to focus clearly on objects at various distances.

Auditory-visual integration The ability to match a sequence of auditory stimuli to a correct visual representation of that sequence.

Automaticity The rapid processing of a visual stimulus that does not require direct cognitive intervention or attention allocation.

Bilateral integration The awareness and use of the extremities, both separately and simultaneously, in unilateral and bilateral combinations.

Directionality The ability to understand and identify right and left directions in external visual space.

Dyslexia A neurocognitive deficit characterized by problems in expressive or receptive, oral or written language. Problems may emerge in reading, spelling, writing, speaking, or listening.

Graphemes The visual representation of letters or words; single letters or letter pairs associated with a particular sound.

Laterality The internal representation and sensory awareness of both sides of one's own body.

Learning disabilities Disorders in one or more of the basic psychological processes involved in understanding spoken or written language including unexpected difficulties in learning in individuals who otherwise possess the intelligence, experience, and opportunity for normal achievement.

Magnocellular pathway A processing pathway from the retina, through the lateral geniculate nucleus to the visual cortex, characterized by fast temporal and low spatial resolution and high motion sensitivity.

Ocular motility A term referring to two types of eye movements, smooth pursuit and saccades, in addition to fixation maintenance.

Phoneme The sound of a letter or letter combination; the smallest unit of speech.

Phonological processing A term referring to the rules associated with the sounds of the language, includes comparison of the beginning, middle, and ending sounds of words, rhyme detection, sound vocalization, and blending, among other skills.

Vergence The disjunctive movement of the eyes in which the visual axes move toward each other or away from each other.

Vision related learning problems Deficits in visual efficiency and visual information --processing skills that affect learning.

Vision therapy A sequence of activities individually prescribed and monitored to develop efficient visual skills and information processing.

Visual closure The capacity to identify an object accurately when incomplete details are available for analysis.

Visual discrimination The awareness of the distinctive features of objects and the symbols of written language.

Visual efficiency A term referring to the basic neurophysiological processes that include visual acuity, refractive error, accommodation, vergence, and ocular motility.

Visual figure-ground perception The ability to select an object or a specific feature of an object from a background of competing stimuli.

Visual information processing skills Higher order functions, including visual perception and cognition, and their integration with motor, language, and attention systems.
Visualization The ability to manipulate a visual image mentally.

Visual memory The ability to recognize or recall previously presented visual stimuli.
Visual-motor integration The ability to integrate visual information with fine motor movements.

Visual persistence The continued perception of a stimulus after it has been physically removed. It reflects ongoing neural activity initiated by the onset of the stimulus.
Visual spatial orientation The ability to understand directional concepts, both internally and projected into external visual space.

Visual-verbal integration The rapid retrieval of a verbal label for a visually presented stimulus.