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An Ophthalmologist's Approach to Visual Processing/Learning Differences

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In the past, most ophthalmologists read or were told that treatment of the disorders affecting children with dyslexia and other learning disabilities fell outside the field of ophthalmology because the brain, and not the eyes, is the main organ active in the process of thinking and learning (Hartstein, 1971; Hartstein & Gable, 1984; Miller, 1988). Because dyslexia, for example, implied an inability to understand the written word, the definitive diagnosis and therapy was in the hands of the educators and clinical psychologists, not the ophthalmologist. The role of an ophthalmologist, thus, was to rule out disease as the first step in determining the reason for a learning difference before referring the child back to the pediatrician or family doctor for further evaluation and referral.

This limited role for ophthalmologists in treating children with learning disorders is now being displaced by a move toward an interdisciplinary approach. The ophthalmologist is often the first expert to whom the pediatrician refers a child suspected of having a learning disorder. Educating ophthalmologists in the medical and nonmedical conditions and situations that could affect learning in a child or older individual will help ensure that a patient receives appropriate, effective, and timely remedial treatment.

The first step in educating ophthalmologists is to introduce psychiatry, educational and neuropsychology, physical and occupational therapy, and educational science in all its forms relating to learning differences in children and adults to the ophthalmology community (Koller & Goldberg, 1999). (An appendix to this chapter outlines briefly what an ophthalmologist in general practice should know about learning disorders.) The second is to make the diagnosis and treatment of children more efficient by developing a system for classifying disorders that is oriented toward ophthalmologists. This chapter describes such a classification system for learning disorders. It then goes on to describe causes and treatment of medically based ophthalmic problems affecting learning, as well as other conditions affecting learning that are not purely ophthalmic but which ophthalmologists can help diagnose (Koller, 1999a).

AN OPHTHALMOLOGIST'S CLASSIFICATION APPROACH TO LEARNING DISORDERS

Children with learning disabilities can be classified into two main groups: (1) those with purely medically and surgically treated ophthalmic disorders that temporarily or

chronically affect learning efficiency in school (DSM-IV: Axis III – general medical conditions), and (2) those with conditions not purely ophthalmic that traditionally have fallen into the243 fields of the cognitive sciences and education (DSM-IV: Axis I). The second group of conditions can be subdivided into the four traditional types of learning differences: (1) developmental speech and language disorders, (2) nonverbal learning disorders, (3) attention disorders, and (4) pervasive developmental disorders (PDD). Many of these have observable ophthalmologic findings. The social reasons for deficient learning in school, such as dysfunctional family environment, poor instruction, foreign first language, and severe psychiatric disease are not directly associated with eye abnormalities (DSM-II and IV). The next section discusses the causes and treatment of disorders within the first main group; that is, medical conditions that temporarily or chronically affect learning.

Ophthalmic Causes of Learning Difficulties

There are several purely ophthalmic causes of temporary or chronic learning difficulties. Many times these conditions cause intermittent blurry vision in school and at home, itchy eyes, redness, foreign body sensation, various visual phenomena, double vision, tearing, light sensitivity (photophobia), and ocular pain and headache. All of these symptoms can affect children's concentration in the classroom and at home and their ability to learn efficiently (Koller, 1997). The main categories of ophthalmic causes affecting learning are refractive errors, strabismus and amblyopia, nystagmus, systemic diseases affecting the eyes, local ocular diseases, and neuro-ophthalmic disorders.

Refractive errors are optical refractive imperfections due to the size and shape of the focusing structures of the eyeball (globe) itself. Refractive status is inherited, with the eyeballs of children shaped like the eyeballs of their parents. A nearsighted eye (myopia) is longer, and the light is focused in front of the retina. A farsighted (hyperopia) eye is shorter, and the light is abnormally focused in back of the retina, not on it. An astigmatic eye is one in which the cornea in front or the lens in the middle of the eye is misshapen microscopically like a lemon or football, more curved in one direction than the other, 90 degrees away. A blurry image results from all three refractive abnormalities (Reinecke, 1965). A corrective spectacle lens is necessary to refocus the light rays coming from the objects observed to create a sharp focused image on the retina, which is then transmitted to the brain so a person can interpret what is seen clearly.

Strabismus is the condition of misaligned eyes in which the eyes are not aimed in the same visual direction. The eyes may be divergent (exotropia or walleyes), convergent (esotropia or crossed eyes), or vertically apart (hypertropia). They also can be cyclotropic, or misaligned around an anterior-posterior axis through the pupil, which can cause significant visual confusion and image "tilt" or torsion. Most acquired strabismus can cause double vision (diplopia), which is most annoying to school-aged children. Less frequently, the sudden onset of strabismus with diplopia in a school-aged child or younger may be of paralytic etiology as a result of a virus infection, or even a brain tumor. The paralysis in the latter case is due to one of the three cranial nerves innervating the six extra-ocular muscles in each eye being affected. A thorough medical evaluation is mandatory (Parks, 1975).

Treatment for exotropia is usually surgical, although for small deviations and those less severe cases in which the eyes go out more at near (convergence insufficiency) than

in the distance (divergence excess), eye exercises in the form of classic orthoptics or optometric vision training is quite acceptable. The idea is to train diplopia awareness to improve fusional convergence amplitudes. This enables the individual to see and focus singly over a broader area of viewing and for a longer duration (Bedrossian, 1969). Treatment for nonparalytic esotropia (the eyes are crossed in but move normally in all directions and to the extreme gaze positions) is usually surgical or optical (eyeglasses) if there is excessive farsightedness. In such a case, the eyes over-focus and turn in too much. The hyperopic power of the glasses assumes the focusing function and, when the lenses are worn, the eyes do not have to focus to see clearly and the eyes remain straight. If the eyes turn in more at near than in the distance, bifocal eyeglasses are required to cause more focusing relaxation close up. There are cases, however, involving both esotropia mechanisms that require both glasses and, for the portion of deviation not controlled by the eyeglasses alone, surgery. If left untreated, the weaker eye may develop suppression in order to avoid double vision and become amblyopic. Paralytic as well as restrictive esotropia patients often present with face turns to preserve use of their eyes together away from the side of the paralyzed eye muscle. This can sometimes interfere with efficient reading. Treatment is often surgical.

Hypertropia or vertical strabismus comes in a variety of forms but often it presents to the pediatrician or ophthalmologist as a head tilt, chin depression, elevation or face turn, or combinations of these abnormal head postures. These can all interfere with normal navigation as well as with reading and learning. The treatment is usually surgical. One common such condition is congenital fourth nerve palsy; head tilt is the presenting sign. One should also be aware of the so-called "A" and "V" syndromes in which the eyes go "in" or "out" more in one gaze than in another. For example, a "V"-pattern esotropia is one in which the eyes go in more when looking down than when looking up, which could cause double vision when reading. Treatment is either with bifocal eyeglasses or surgery if spectacles are ineffective.

Amblyopia is the term applied to diminished vision without an obvious physical or structural abnormality present to account for the vision loss (Simon & Calhoun, 1998). It is called "organic amblyopia" when the vision loss is due to a structural defect such as an abnormal optic nerve. The lay term for amblyopia is "lazy eye," which people often confuse with strabismus or "a weak eye muscle." A more appropriate term for amblyopia would be "lazy vision." There are three types of amblyopia: (1) refractive, due to the eyes having different refractive errors and focusing ability; (2) strabismic, in which the eyes are not aimed at the same object, causing diplopia to occur; and (3) occlusion amblyopia, in which one eye has unclear or opaque media inhibiting light from being clearly transmitted from the environment to the retina, such as a cataract.

For vision to develop normally, both eyes must be in focus, see clearly, be aligned straight ahead, and maintain coordinated eye movements in all fields of gaze. If this does not take place, the lateral geniculate body in the brain develops ganglion cell degeneration and a subsequent decrease in visual acuity. The cause of this in the refractive type is one blurred retinal image in the affected eye and one clear image in the more normal eye. The brain automatically shuts off the blurry image and the cells in the lateral geniculate body atrophy. Giving these patients the correct eyeglasses and covering the better eye with a patch to cause the cells to regenerate is the best therapy. The earlier this is done, the

easier it is for the cells to regenerate and the better the results. The brain becomes less plastic after age six and often does not respond to occlusion therapy after puberty. In the strabismic type, eyeglasses or surgery to eliminate the malalignment of the eyes, preceded and followed by occlusion therapy over the better eye, is the best treatment. In occlusion amblyopia, surgical therapy to remove the cause of the obstruction is performed first, followed by appropriate optical correction. A contact lens, or intraocular lens in the case of a unilateral cataract in a child, is currently the best therapy. Amblyopia is reversible if diagnosed early. However, treating school-aged children is frequently a challenge due to peer ridicule and the child's lack of compliance with eye patching. Schoolwork and learning can be affected because the patch covers the better eye. Alternatives to patching include cycloplegic eyedrops, such as atropine and cyclopentolate, to blur the vision in the better seeing eye as well as oral levodopa. L-dopamine seems to improve amblyopic vision in some individuals, even after adolescence, although this drug is not yet in widespread use in the United States (Leguire, Rogers et al., 1998).

Nystagmus is repetitive movements of the eyes, usually horizontally to-and-fro with a fast jerk in one direction (Reinecke, 1997). The movement may be only horizontal or vertical and rarely torsional, but more often it is a mixture. Nystagmus is typically stable in any specific field of gaze, which is termed the "null point." There are many types of nystagmus based on description of the pattern and on the etiology. Examples include vestibular nystagmus, latent and manifest latent nystagmus, amaurotic or "blind" nystagmus (which is more a searching, than jerking movement), and idiopathic infantile nystagmus. The latter is seen in patients with albinism and various retinal disorders. Occlusion amblyopia can cause deprivation nystagmus, which decreases or is entirely eliminated when the obstacle to normal focusing is removed. Many types of nystagmus are associated with less than normal vision and often a null point exists in one field of gaze, causing a head tilt or face turn in order to achieve optimal visual acuity that exists in the field of least nystagmus activity. Treatment in some cases is surgical in order to move both eyes and the null point away from the extreme gaze position of the null zone and to the primary straight-ahead position. Reading can be labored for children and adults with nystagmus, and learning is therefore sometimes compromised.

Systemic disease affecting the eye and disrupting normal visual learning processes most commonly include (1) juvenile rheumatoid arthritis; (2) metabolic and endocrine disorders, such as juvenile diabetes or pituitary disorders; (3) blood dyscrasias affecting the eye and brain, such as leukemia; and (4) metastatic neoplastic disease to the eye and/or brain, such as neuroblastoma. All of these diseases are treated medically and surgically, as required. Disruption of schooling often occurs for significant periods of time in the more serious cases. Learning is thus secondarily compromised even if no basic learning disorder was present before the child became ill. If the brain becomes structurally involved in the disease process, the various learning centers can be directly affected, causing a possible permanent learning disorder.

Local ocular causes of decreased vision include:

- Ocular media opacities, such as opaque corneal lesions and cataracts.
- Congenital and infantile glaucoma (high intraocular pressure frequently causing legal or complete blindness).

- Significant unilateral and bilateral ocular trauma causing moderate to severe vision loss, such as rupture of the globe after falling on a sharp object.
- Ocular and adnexal neoplasms with secondary disfigurement and/or vision loss, such as retinoblastoma and rhabdomyosarcoma of the muscles of the globe or eyelids.
- Severe chronic ocular infections, such as Herpes Simplex Virus–I, with vision loss affecting the cornea.
- Congenital and degenerative retinal or optic nerve diseases affecting the macula or optic nerve, such as toxoplasmosis and optic nerve hypoplasia (small, poorly functioning optic nerve).

These are frequently seriously urgent conditions, often requiring surgery, chemotherapy, or other medical treatments to cure or control. Schooling and learning invariably suffer (Miller, 1988).

Neuro-ophthalmic causes of temporary or intermittent learning impairment and inefficiency include two broad categories frequently seen in the pediatric ophthalmologist's office: (1) primary brain diseases and tumors causing personality and behavior changes and (2) the vast variety of vascularly mediated pediatric migraine syndromes.

Classic migraine involves a vascular-mediated headache, often preceded by various visual auras, photophobia, and nausea. It is usually followed by the desire to sleep, after which the headache often is gone. Children frequently present with a variation termed "acephalgic migraine." Headaches are not usually a part of the presenting symptom complex. This fact often confuses the parents and many professional caregivers who expect migraine to always be a headache. Children who complain of blurry vision in school but who are found to have a normal eye evaluation may merely be experiencing the pediatric equivalent of adult, constricting visual fields and the typical "scintillating scotoma." These aura are often termed "ophthalmic migraine" when headache symptoms are minimal or absent in adults. Children have a number of associated signs and symptoms of pediatric migraine. These para-migraine entities include infantile colic, lactose intolerance, sleep disturbances (including night terrors and nightmares), and motion sickness. They also include frequent febrile seizures; unexplained abdominal discomfort; allergic predisposition; unusual sensitivity to light (photophobia), noise, and smell; and a type-A personality resistant to change with occasional obsessive/compulsive behavior. Para-migraine entities may also be characterized by various other visual phenomena, such as micropsia (things looking smaller or farther away), macropsia (things looking larger or closer), and metamorphopsia (things looking distorted, as in a fun house mirror). The classic description of the latter is the so-called "Alice in Wonderland" syndrome.

Children complaining of any of these symptoms, either as a single symptom or in combination, sometimes are not believed or are misunderstood, leading to a misdiagnosis or no diagnosis at all. A pediatric examiner must ask the parents of children with learning differences and difficulty with schoolwork if these symptoms occur to ascertain whether or not para-migraine complaints exist. A pediatric neurologist is best for advising these families about acephalgic pediatric migraine therapy. More severe pediatric vascular migraine can result in the syndrome of ophthalmoplegic migraine, which is manifested by paralysis of one or more extraocular muscles with resultant strabismus and diplopia. In these cases, a pediatric ophthalmologist should be consulted. More serious conditions such as a brain tumor must be ruled out. A

migraine predisposition must be considered in any child with a learning problem. Migraine is definitely familial and inherited in a multi-factorial mode with various family members having different combinations of symptoms (O'Hara & Koller, 1998).

The following section discusses conditions that are not purely ophthalmic, but some of which may have ophthalmologic findings. These include receptive language disorders, a nonverbal learning disorder, and some pervasive developmental disorders.

COGNITIVE AND EDUCATIONAL CLASSIFICATIONS IN LEARNING DISORDERS

Speech and Language Disorders

Articulation and expressive language disorders (Koller, 1999b) can be grossly diagnosed by taking a history of the child from the parents and observing the child speaking or not speaking while seated in the exam chair. If the parents have not yet sought professional help, the child can be referred back to the pediatrician, an ear, nose, and throat specialist, or a speech and language pathologist for further evaluation and therapy with the primary care physician's knowledge and consent. The ophthalmologist is not directly involved in the specific diagnosis or treatment of children with these disorders.

Receptive language disorders, in contrast, involve visual processing and perception and should be more thoroughly analyzed by the pediatric ophthalmologist. Realizing that developmental dyslexia is now thought to be a result of a genetically inherited deficiency (Shaywitz, 1998) in cerebral phonetic analysis, the ophthalmologist can deduce the likely presence of dyslexia from the family history and by asking the child a few questions about simple words, such as "cat" and "bat," in an attempt to bring out the inability of such children to identify the components of "bat" as "bu," "aah," and "teh." A history of letter reversals in school and difficulty reading may not really point to a receptive language disorder alone because nonverbal learning disorders and attention disorders can also cause these symptoms in certain instances. Early preschool identifying characteristics include unusual difficulty learning numbers, letters, and colors without evidence of eye disease. The ophthalmologist should refer these children to a knowledgeable neuropsychologist or speech and language pathologist for further testing to identify all the specific language disorders existing in each individual case and then to recommend diagnosis-specific therapy. A licensed reading teacher and a homework tutor may both be required, with additional therapy and monitoring by the speech and language pathologist and the neuropsychologist as necessary.

Auditory processing disorders are in the realm of ear, nose, and throat specialists, as well as speech and language pathologists, and should be referred to those professionals for appropriate, specific diagnoses and therapy (Welsch, 1980; Welsch & Healey, 1982). A tutor is often helpful to teach auditory interpretation and attention in the classroom environment. Auditory processing disorders are receptive language dysfunctions and the "hearing" equivalent of "visual" developmental dyslexia. One remedial method in reading disorders is to have the child simultaneously listen to a recording of the written text while following the printed material in the book in the presence of a reading instructor. This therapy is effective if only visual or auditory processing is abnormal, not if the child suffers from both disorders.

Nonverbal Learning Disorders

Appropriate diagnostic studies establish this all-too-often missed learning disorder.

The ophthalmologist can suspect a nonverbal learning disorder (NVLD) by giving the young patient a simple visual memory test in the office. It takes only 1 to 2 minutes to perform. (See Figure 1.) NVLD is thought to be associated with right hemisphere white matter dysfunction (Bannatyne, 1974; Foss, 1991; Johnson & Myklebust, 1967). The frontal lobe may also be involved. The main deficits of this disorder include visual-spatial perception, visual memory, psychomotor coordination, complex tactile-perceptual skills, reasoning, concept formation, mathematical abilities, and psychological/behavioral difficulties.

Well-developed verbal and reading skills, however, are frequently observed in these children and adults. Occupational therapy is the treatment path that is most efficient for individuals with NVLD. At times, therapy must be coordinated with a homework tutor, reading specialist, and/or a physical therapist if other, more complex aspects of NVLD are identified. Numerous treatment strategies have been tried over the years but utilizing current repetitive, standard rehabilitation science techniques seem, at present, to be best.

It is in this category of learning differences that some optometric vision training techniques appear to be effective. These techniques are partially based on occupational and physical therapy principles as well as standard rehabilitation science. Adults, after

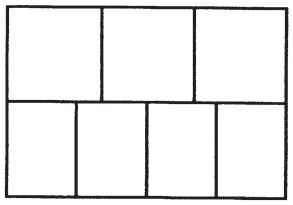

Figure 1a

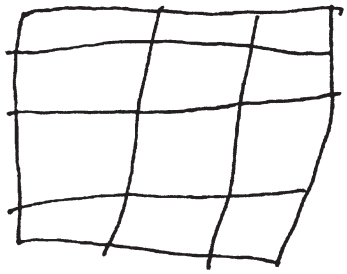

Figure 1b

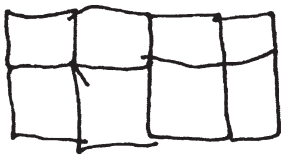

Figure 1c

Figure 1a-1e. – A Diagnostic Tool for Categorizing Nonverbal Learning Disabilities in School-aged Children 6 to 12 Years Old

(A simple pattern [1a] is presented to a child for 15 seconds. The child is then asked to draw the pattern from memory. Figures 1b and 1c are examples of acceptable normal variations in children's drawings. Figures 1d and 1e represent variations that indicate a possible nonverbal learning disorder.)

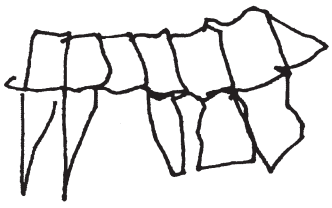

Figure 1d

Figure 1e

strokes, as well as all-aged individuals after accidental closed head trauma, are taught to utilize the uninjured functioning parts of their brain to compensate for loss of normal use of an injured or damaged brain area, despite the fact that the area of the brain assuming the new function was never intended to do so. Stroke patients thus learn to read, write, talk, and navigate once again despite permanent brain damage to the area previously programmed to maintain those particular functions. A similar model exists for children with naturally occurring brain dysfunction, such as the one for nonverbal learning disabled individuals. These children are born with inefficient or inadequate brain programming and processing. Laterality training, eye movement coordination strategies to help create smooth pursuits (saccades), and hand-eye coordination exercises all help improve, to some extent at least, performance of those functions. To what direct extent learning itself, in a classroom or at home, is enhanced in all cases has yet to be shown via evidence-based science using a masked or double masked controlled study. Published studies reviewed by the author to date are anecdotal or retrospective/prospective reviews of measurement parameters or performance, often while other remedial methods are carried out simultaneously (Atzmon et al., 1993).

Piaget's theory stating that "intelligence is the most important instrument of learning" and that environmental interaction is equally important has been used as the basis for utilizing games and play as a medium to enhance the process of thinking and learning. This was tried in a West Virginia school setting by Furth and Wachs more than 25 years ago (Furth & Wachs, 1974). Developmental optometry has adopted some of Piaget's theory for vision training. The idea is to think before you can actually learn a fact or concept.

Some optometric exercises (Scheiman, 1994) are designed to improve developmental visual information processing. The first goal of therapy is to develop the patient's motor-awareness ability by performing isolated, simultaneous, and sequential movements involving both sides of the body. The treating optometrist wishes to develop motor memory of the differences between the right and left sides of the body. This is typically accomplished using balance activities, ball bouncing, chalkboard squares, and other gross eye-hand coordination activities such as beanbag tossing or ball playing. The second goal of therapy is to develop the patient's motor-planning ability. This is accomplished using numerous other techniques, including jumping jacks, the Randolf shuffle, and slap-tap, among others. These strategies seem to work by repetitive, positive psychological reinforcement and one-on-one patient-therapist interaction as much as by direct influence on the cerebral academic learning process itself. Since NVLD involve higher cognitive learning centers in which abstract thinking, visual memory, and spatial recognition are the main deficits, repetitive training makes it possible for a child to learn to perform certain tasks more efficiently. "Practice make perfect" is a commonly accepted theme. If a child with NVLD is taught by optometric techniques to enhance motor memory, motor awareness, and motor integration—and this improvement can be transferred to the academic arena—then the claimed benefits of optometric vision training can be realized. Those who profess benefits from vision training in cases of speech and language disorders, attention disorders, and pervasive developmental disorders (including classic autism) are simply not reporting the other therapies for these individuals being carried out simultaneously by other professionals, including pediatric neurologists, psychiatrists, psychologists, language therapists, occupational therapists, physical therapists, educators, and pediatricians. NVLD account for less than 15% of all learning disabled individuals (Koller, 1999b). Vision

therapy is but one of many interdisciplinary interventions necessary for these individuals.

Attention Deficit/ Hyperactivity Disorders

The diagnosis of attention deficit/hyperactivity disorders (ADD/ADHD) is established by the criteria listed in the DSM-IV, with behavior repeated over time. Some controversy still exists concerning the real existence and definition of these two diagnoses as a separate category of learning disorders (Carey, 1999). The pediatric neurologist, pediatric developmental specialist, family pediatrician or physician, or psychiatrist usually provides treatment. It is necessary for the ophthalmologist to identify the behavior by listening and observing while the child is in the examination chair and referring appropriately. Pharmacological therapy is the treatment of choice, with ancillary remediation from homework tutors, certified reading specialists, and, occasionally, occupational therapists. Teaching a child to concentrate quite often appears to be easier when the patient is on stimulant therapy such as Ritalin or Adderal. Nonetheless, many pediatric neurologists and pediatric developmental specialists now prefer to reserve drug therapy for more persistent cases.

The Committee on Quality Improvement (Subcommittee on Attention Deficit/Hyperactivity Disorder) of the American Academy of Pediatrics (2000) recently published its clinical practice guidelines, *Diagnosis and Evaluation of the Child with Attention Deficit/Hyperactivity Disorder,* which emphasizes to pediatricians the DSM-IV criteria for diagnosing ADHD and observing the typical behaviors in more than one setting, location, and situation over time. Research involving the study of academically efficient individuals with ADHD compared to those afflicted who are scholastically inefficient was suggested.

Pervasive Developmental Disorders

The ophthalmologist can frequently identify an individual with Asperger's syndrome or Rett syndrome by history and observation of the patient's behavior in the examination chair. Lack of eye contact is often the initial complaint and reason for referral to the ophthalmologist (Koller & Goldberg, 1999). Lack of social relatedness and peer interaction is obtained by the ophthalmologist from the family and patient history. The history can also provide information concerning an intense area of interest or other behavior peculiar to individuals with autistic spectrum disorders. Definitive diagnosis and treatment should be in the hands of a qualified psychiatrist and knowledgeable pediatricians, as well as occupational and physical therapists, who are well schooled in diagnosing and treating children with pervasive developmental or autistic spectrum disorders (PDD/AS) (Greenspan & Wieder, 1998). The role of the ophthalmologist is to suspect the diagnosis and refer appropriately, noting the high index of suspicion.

"Vision training" techniques have yet to be shown to directly influence the main deficits of autistic individuals. However, some vision training techniques and occupational therapy are appropriate for nonverbal learning disorders that are part of an autistic individual's component disabilities. Since the autistic spectrum involves people with difficulties in social relatedness and social skills, use of language for communicative purposes, and a limited but intense range of interest, many different professionals must become involved in ongoing therapy. Any eye abnormality present should be corrected by the ophthalmologist, just as an appropriate specialist should treat any medical condition. If the patient is sufficiently functioning and can concentrate on occupational and/or vision therapy tasks,

these tasks should be provided for those component disorders the PDD/AS patient manifests. There is much to be learned in the future from studying these remedial methods with evidence-based science. Optometrists, ophthalmologists, occupational therapists, and speech and language pathologists should work together to bring about this research.

OTHER DISORDERS AFFECTING LEARNING

Other disorders affecting learning that an ophthalmologist frequently sees include Tourette syndrome and some purely mental disorders such as anxiety disorder, oppositional defiant disorders, and personality disorders (Axis-I). Idiopathic sleep disorders can also affect learning, as can social and family dysfunction or poor school instruction (Axis-IV). All these conditions can be suspected from a social and family history taken by an ophthalmologist in the office. Tourette syndrome is often treated by a pediatric neurologist or psychiatrist, whereas a pediatric psychiatrist most effectively handles the other conditions mentioned.

Several serious genetic disorders are frequently associated with learning differences, including familial dysautonomia (Reilly-Day syndrome) (Groom, Kay, & Corrent, 1997) and mitochondrial cytopathy (Phillips & Newman, 1997). Both these conditions involve multiple systems within the body. The brain is a high oxygen/energy uptake organ and the mitochondria are the oxygen generators of our cells. Any disease of the mitochondria affects most organ systems. The autonomic nervous system is almost nonfunctional in familial dysautonomia, and brain processing is also affected. Much more research in the area of mitochondrial (not nuclear) inheritance must be done to correlate learning disabilities with these conditions. Familial dysautonomia may also be a partial mitochondrial disorder, as might many other types of learning differences and disabilities.

CONCLUSION

As noted previously, having the ophthalmologist aware of all of the medical and nonmedical conditions and situations that could affect learning in a child or older individual increases the potential for a child with learning disabilities to receive appropriate, effective, and timely remedial treatment. It is important for one professional to take the responsibility of coordinating all the specialists actually involved in the care of any patient with a learning difference. It doesn't matter what that person's specialty is, so long as he or she is knowledgeable in the general field and has the motivation, passion, and resources necessary to coordinate the efforts of numerous physicians, psychologists, educators, and allied health professionals, such as occupational therapists, physical therapists, optometrists, and speech and language therapists. Social workers and attorneys often are involved, too. Given the desire, an ophthalmologist can assume this task easily. The ophthalmologist is often the first expert to whom the pediatrician or family physician refers the child suspected of having a learning difference. However, the pediatric psychiatrist, neurologist, or developmental specialist could be equally effective. True multidisciplinary science and coordination of effort is mandatory if optimal benefit is to be achieved for all individuals with learning disorders. ■

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Appendix

VISUAL PERCEPTION AND LEARNING DIFFERENCES IN PEDIATRIC OPHTHALMOLOGY: What the Ophthalmologist Needs to Know about Learning Disabilities in Clinical Practice

I. Ophthalmic Causes of Temporary Learning Impairment and Inefficiency

A. Strabismus, amblyopia, and refractive errors
   1. Decompensated accommodative esotropia with secondary diplopia
   2. Secondary ocular cranial nerve palsies (n. III, IV, VI)
   3. Uncorrected congenital vertical strabismus with abnormal face and head positions
   4. Bilateral very high ametropias, such as bilateral amblyopia of high hyperopia
   5. Bilateral occlusion amblyopia, such as after congenital cataract surgery
   6. Associated untreated "A" and "V" syndromes
   7. Convergence insufficiency exotropia/phoria in certain individuals

B. Nystragmus of moderate to severe degree causing significant vision loss

C. Pediatric ocular diseases that can affect learning via visual and emotional effects
   1. Severe juvenile rheumatoid arthritis and related ocular inflammations
   2. Congenital glaucoma with vision loss
   3. Congenital cataracts and major corneal opacities with vision loss and nystragmus
   4. Significant unilateral and/or bilateral ocular trauma with vision loss
   5. Ocular and adnexal neoplasms with secondary disfigurement and vision loss
   6. Severe chronic ocular infections such as HSV-I with vision loss
   7. Congenital and degenerative retinal diseases affecting the macula

II. Neuro-ophthalmic Causes of Temporary or Intermittent Learning Impairment and Inefficiency

A. Brain tumors causing a change in personality and behavior in a pediatric patient

B. Migraine syndromes
   1. Acephalgic pediatric migraine with visual disturbances and variable vision in school
   2. Ophthalmic migraine in childhood
   3. Ophthalmoplegic migraine
   4. Classic migraine in the older student

C. Optic nerve disease with significant visual impairment

III. Systemic Diseases Associated with Vision and Neurologic Dysfunctions Potentially Affecting Learning

A. Metabolic and endocrinic disorders

B. Blood dyscrasias affecting the eye and brain

C. Metastatic neoplastic disease to the eye and/or brain

IV. The Ophthalmologist's Role in Examining a Child and Advising the Family of a Defect in visual processing and/or learning is to rule out the presence of eye disease or related systemic disorder and to refer the pediatric patient to the proper professionals for more definitive diagnoses and subsequent treatment(s). In order to effectively do this, a classification of non-ophthalmic learning disorders will now be outlined.

A. Learning disabilities (differences)
   1. Developmental speech and language based disorders (epidemiology)
      a. Articulation disorders
      b. Expressive language disorders
      c. Receptive
         (1) Dyslexia—phonologic processing disorder
            (a) genetics
            (b) pathophysiology
            (b) remediation
            (d) early preschool identifying characteristics
         (2) Other receptive language disorders
   2. Nonverbal learning disabilities (epidemiology)
      a. Definition
      b. Characteristics and affected areas of learning
         (1) visual-spatial perception
         (2) visual memory
         (3) psychomotor coordination
         (4) complex tactile-perceptual skills
         (5) reasoning
         (6) concept formation
         (7) mathematical abilities
         (8) psychological behavioral difficulties
         (9) good verbal and reading skills
      c. Early identification traits
      d. Differential diagnosis
      e. Methods of treatment. What exactly is optometric vision training?
      f. Rationale of therapy based on the traditional closed head trauma/stroke rehabilitation model
   3. Attention deficit hyperactivity disorder (epidemiology)
      a. Definition
      b. Characteristics (DSM-IV) and diagnostic criteria observable during an eye exam
         (1) squirms in seat, fidgets with hand and/or feet
         (2) unable to remain seated when required to do so
         (3) easily distracted
         (4) blurts out answers before a question is finished
         (5) difficulty following instructions
         (6) unable to sustain attention in work activities
         (7) interrupts or intrudes on others

(8) does not appear to listen
(9) loses items for tasks such as toys, pencils, and books
(10) often engages in dangerous activities without considering the consequences

c. Subclassification
(1) inattention
(2) impulsivity
(3) hyperactivity

d. Differential diagnosis
(1) Tourette's syndrome
(2) conduct disorder
(3) oppositional defiant disorder
(4) other tic disorders

e. Treatment and community support
(1) pediatric neurologist
(2) pediatric developmental specialist
(3) pediatric psychiatrist
(4) special education teacher or tutor
(5) various support groups

4. Pervasive developmental disorders/autistic spectrum disorders (PDD/ASD)
a. Definition
b. Characteristics: defects in social relatedness and language/communication skills
c. Subclassifications
(1) Asperger's syndrome (chief eye symptom is "lack of eye contact")
(2) Rett syndrome
(3) classic autism
(4) unclassified PDD/ASD
d. Referral and treatment options
e. Micro and primary dyskinetic strabismus as a presenting sign of PDD
f. Hyperlexia

V. Patient Support Groups for Learning Disabled (LD) Individuals

A. CHADD (Children and Adults with ADD)
B. CEC (Children's Educational Counsel)
C. ASLHA (American Speech, Language and Hearing Association)
D. LDAA (Learning Disabilities Association of America)
E. PERC (Parents Educational Resource Center)
F. The Orten Dyslexia Society
G. AHA (American Hyperlexia Association)
H. HALO (Health Achievement Learning Opportunities Centers)

VI. Role of the Pediatric and Comprehensive Ophthalmologist Concerning Individuals with Learning Disabilities

A. Identify and treat any eye or eye-related systemic disease or abnormality.

B. By observation and careful history, identify which broad category of learning differences the patient likely has and convey that impression to the pediatrician, the family, and any other interested parties. These children have often been through many psychological tests, tutoring, and other attempts at remediation without a definitive diagnosis or combination of diagnoses. Suggest a comprehensive neuropsychologic/educational evaluation from a qualified, credentialed neuropsychologist when all interested parties agree.

C. Help the family by giving them a direction in which to proceed so that the child with non-ocular learning differences can start to achieve his full potential. Not every individual with learning disabilities requires every possible specialist. These professionals include:

1. Pediatric neurologist
2. Pediatric psychiatrist
3. Pediatric developmental specialist
4. Pediatric endocrinologist
5. Pediatric geneticist
6. Pediatric otolaryngologist
7. Pediatric ophthalmologist
8. Speech and language pathologist (audiologist)
9. Neuropsychologist
10. Educational psychologist
11. Educator with special education credentials
12. Reading tutor
13. Physical therapist
14. Occupational therapist
15. Pediatric social worker
16. School placement expert (educator)
17. Disabilities attorney
18. Family physician or general pediatrician

D. A specialized attorney is often beneficial for helping families receive federal LD benefits to which they are entitled under the terms of the Individuals with Disabilities Education Act (IDEA) and Americans with Disabilities Act (ADA).

E. When the answer the question, “Is the child’s reading and/or learning problem in school due to his eyes?” is “No,” the ophthalmologist must explain why it is not and offer a positive and constructive method to direct those families toward obtaining the proper and appropriate care. The public still believes that eye specialists are knowledgeable in the field of visual perception as well as visual function.