Considerations in Evaluation and Treatment of the Child With Low Vision

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Habilitation of infants and children with visual impairments should be based on a thorough understanding of their visual capabilities and limitations. Comprehensive evaluation of visual function includes measurement of visual acuity, contrast sensitivity, visual field, color vision, adaptation, visual sphere, accommodation, and oculomotor functions. It is best completed through a team approach that uses therapists, special educators, and physicians. A complete evaluation also includes examination of the effect of other motor functions on the use of vision. Nearly all aspects of a child's vision can be measured in play situations with tests that are easy to use. However, further education of nonphysician team members in refractive errors, optics, and function of optical devices may be necessary to ensure an accurate and thorough evaluation.

Central Versus Peripheral Lesions

The first question that must be answered with regard to the child's vision loss is if the visual impairment is caused by a peripheral or central lesion of the visual system or a combination of both types of lesions. Peripheral lesions involve the pathway between the eye and the primary visual cortex including the eye itself, the optic nerve and optic chiasm, and tracts to the lateral geniculate nucleus. Impairments caused by peripheral lesions result in a decrease in the quality of the visual image. The poor quality of the image can often be compensated for by increasing contrast and by simplifying the visual structure of the pattern presented. For example, the child with a peripheral lesion can be presented with

1Peripheral visual lesions can be demonstrated to a certain degree. Opacities of the optic media can be simulated by using ordinary kitchen wrap and folding it several times. When one looks through the folded wrap, fine details are invisible but large objects can be recognized. Tubular field can be simulated by pasting translucent tape on spectacles (Hyvärinen, Sorri, & Gimble, 1990). The diameter of the tubular field is measured at 2 ft, at the distance of 2 ft, 1 cm is equal to 1° of visual angle. If the clear area seen is 10 cm in diameter at 2 ft, one's functional visual field is 10°. It is impossible to simulate visual disturbance related to diffuse retinal lesions where the image is in flickering motion or where there are different small lights floating around in the visual field. Central visual impairment is impossible to simulate. We must listen to these persons carefully, observe their visual behavior, and try to imagine what kind of visual information they might have. Many children with brain damage have normal or nearly normal subcortical visual functions, (i.e., they have normal visual orientation in space without bumping into obstacles and they can reach for things based on visual information, but they may not look at things). Cortical lesions vary from circumscribed local lesions to diffuse involvement of nearly all areas of the cortex. Functional vision losses may be limited to specific tasks like recognition of faces or comparison of more complicated patterns or may cause more general visual agnosia.
only a few toys that have simple forms and markings and are placed against a contrasting background to make them more noticeable and recognizable.

Central lesions occur in the geniculocalarine tract, the primary visual cortex (also called area 17 or V1), and the visual association areas of the cortex in the occipital lobe, posterior temporal lobe, posterior parietal lobe, and frontal lobe. Other brain lesions create deficits in higher level visual perceptual processing including visual attention, visual memory, spatial concepts, and visual-motor control. When visual impairment is caused by central lesions, it is more difficult to gain an understanding of how the infant or child perceives the world.

**Cortical Visual Impairment**

The term **cortical visual impairment** is used loosely to depict visual impairments that are not understood. When possible, a determination needs to be made as to whether the loss of visual function is related to damage solely in the primary visual cortex (area 17 or V1) or if other cortical areas are involved. If only the primary visual cortex is involved, the subcortical pathway via the superior colliculus and putamen to the parietal associative areas may remain intact, enabling the child to have generally good ability to take in visual information. In lesions confined to the primary visual cortex, the child may have visual acuity up to 5 to 6 cycles per degree, useful levels of contrast sensitivity, intact visual fields, and discrimination of basic colors. However, the child may have difficulty with or be unable to complete basic form discrimination. It is difficult to imagine how the world looks when lines and shapes can be detected but not recognized. A child with cortical visual impairment will have good navigational vision but be unable to use vision to identify pictures or to read (Hyvärinen, 1983). Jan and Groenveld (1993) described in detail the differences in visual behavior between children with anterior or peripheral visual impairment and children with posterior pathway disorders or cortical, central visual impairment.

Deficits in visual attention are often confined to one half of the visual field (hemianissention). In my practice, these deficits are most frequently observed in children who have hemiplegia secondary to cerebral palsy. The child may have a visual field deficit (i.e., a lesion of the anterior visual pathway), hemianissention, or a combination of visual field deficit and inattention. When a functional visual field deficit is present, the child should be made aware of his or her limbs and objects on the blind side. This training should be done gently to avoid startling the child with objects suddenly appearing from the blind half of the field at midline. Children with severe vision loss may not demonstrate any visual attention to objects in the environment. The eyes may be turned up and out as during sleep and the child may show no response to visual stimuli. In some cases, it is possible to activate the child’s visual awareness through the use of palmar activation. To perform palmar activation, the therapist uses his or her thumbs to apply firm pressure in a circular motion on the palms of the child’s hands while bringing the hands to midline. A few years ago, I observed that during such activation the child’s eyes may come to midline and make brief contact with the adult. Repeated use of this technique in therapy combined with intensive effort to communicate with the child may eventually enable the child to bring the eyes to midline without the palmar activation. Some children’s vision can be stimulated by pressing on other activation areas, as used in Asian medical practices (Porkert, 1974; Tappan, 1988). Although not generally accepted by western medicine, such techniques might be tried in the hope that the child will be able to attain a higher level of arousal and begin making visual contact with his or her world.

The child’s ability to bring his or her eyes to midline and make even brief eye contact is of critical importance to the social development of the child and the bonding between the parent and the child. Eye contact is an important prerequisite to social bonding in western cultures. A child who does not make eye contact may be perceived as detached or unresponsive. Although a lack of eye contact is not inherently a problem for the child, it causes the caregiver and even the therapist emotional discomfort that they need to learn to live with. If a child is unable to make eye contact, it is important to train the parents and caregivers in alternative methods to communicate with the child and to help them become more aware of how the child uses other bodily responses to communicate.

Eye contact can be facilitated by turning the child’s face toward the person with whom he or she is communicating. When the child’s head drops forward or backward, as it easily does, it should be returned to the usual communication position. Children with central scotoma (loss of function in the middle of the visual field) have to use an eccentric viewing position of the eye—preferred retinal locus (Schuchard & Fletcher, 1994)—to see visual details. A child with eccentric fixation seems to be looking past an object when focusing on it. Because the child will not be aware that his or her visual communication looks deviant to others, it is important to inform persons who come in contact with the child that, for this particular child, looking past an object is the same as looking at the object. As the child enters the teenage years, he or she may become motivated to assume a more normal looking fixation pattern during communication.

**Visual-Motor Control**

Adequate oculomotor functions are a prerequisite for the child to bring his or her gaze toward the object of interest. When fixation and tracking deviate from norm, the reasons for the phenomenon should be carefully analyzed.
Fixation may not develop at all, and the child may have roving eye movements. When visual tracking skills are not developing, the use of simple objects that smell and taste good and can be easily grasped can be effective tools to train tracking. The child’s own hands are effective visual targets when the child is made aware of them (Hyvärinen, 1994). Training in tracking skills is begun first toward the direction in which the child can most easily move the eyes. Horizontal tracking usually develops first, followed by vertical tracking, and later, circular tracking. Any limitation of the eye movements should be observed and discussed with the ophthalmologist.

Differentiation of eye movements from head movements is likely to be delayed if training is not begun early. In children with low tone, training of differentiated eye movements should begin in infancy. It seems to be easier to train them early, although it is still possible to train them at school age. Similarly, saccadic movements across midline should be trained early to prevent the child from developing a deviant strategy to avoid the midline area such as closing the eyes when approaching midline or making an extra eye movement down or up to get across midline.

The effect of the motor functions on the use of vision may be observed during therapy and reported to the pediatric neurologist, the ophthalmologist, and the parents. Eye–hand coordination may be difficult because of a delay in the diminishing of the child’s early reflex functions. The delay requires careful use of postures and play situations to facilitate the coordination of the child’s vision and hand movements. The most effective postures in facilitating eye–hand coordination, as well as indifferent and inhibiting postures, should be recorded and communicated to everyone involved with the care of the child so they know what to expect when changing the child’s posture during the day.

Evaluation of Vision

Evaluation of visual functions requires medical investigations, optometric evaluation, and observations on how the infant or child uses his or her vision in different situations. In an ideal case, these three types of investigations are summarized and discussed in a team meeting, with each team member contributing information on different aspects of the child’s visual performance. The summary of the findings should focus on the quantity and kind of visual functions that the infant or child has for development of communication, spatial concepts, motor functions, and language. Often, the initial findings must be presented in vague terms and with the understanding that most interpretations are likely to be found incorrect as more information about the child’s visual and other functions is gained later.

Before the therapist begins formal evaluation of the child, information is needed in the following areas:

(a) the structure of the visual impairment in the eye and the visual pathways, (b) an understandable and detailed medical history on the child, (c) the results of the physician’s evaluation of visual function, and (d) the types of optical devices the child is using, their effect on the quality of the image, and problems related to their use. It may be difficult to obtain information on all these areas because changes in the eye and visual pathways are incompletely depicted by the clinical investigations currently available, even when advanced electrophysiologic and radiologic methods are used. In addition, many physicians are not trained to translate complicated medical histories into readily understood terminology. It is also difficult to obtain an accurate functional evaluation during one office visit to the physician; further observation is usually required. Finally, when information is provided on the optical and electro-optical devices the child is using, it may be difficult for the therapists to understand the functions of the devices unless they have a thorough understanding of optics and of the type of visual impairment.

Visual Acuity

Visual acuity is the visual function commonly used to characterize the severity of visual impairment. In adults, visual acuity is measured as recognition acuity. All international, federal, and state regulations are based on visual acuity measured with a line test (i.e., a test where the difference in size between the lines is 0.1 logarithmic unit and where the space between the optotypes [symbols] is equal to the width of the optotypes) (see Figure 1). Such tests require a developmental level of at least 18–30 months and thus cannot be used in examination of infants and many children with multiple handicaps or visual impairments. Therefore, the standard visual acuity limits, like legal blindness, cannot be used to determine the need for early intervention services.

Visual acuity in children is generally measured with grating acuity tests. These tests measure resolution of a much larger area than an optotype test. In a grating acuity test, the person detects the presence of parallel lines of decreasing width—a task much simpler than recognition of an optotype. With impaired vision, grating acuity does not predict future recognition acuity well enough to be used as the basis for decisions regarding qualification for rehabilitation services. The child’s needs for special services should be based on a more holistic observation of the child’s visual limitations.

The prerequisites of clinical measurement of grating acuity can best be unraveled by observation during therapy (Hyvärinen & Appleby, 1995). Therapists and special educators can measure visual acuity with both visual acuity and grating acuity tests, but the administration of these tests requires training. The manuals that are included with the tests give detailed information on testing procedures. Near vision is more important in young children.
than distance vision. When measuring visual acuity, it is important that the refractive correction fit the test distance used. Therefore, information on refraction from the ophthalmologist or optometrist is useful. All measurements should be made within the visual sphere of the infant or child.

**Visual Sphere**

Visual sphere is the distance within which the infant or child can respond to an object of a certain size, contrast, color, and speed of movement. The child’s interest in the object plays an important role in his or her response, so small objects with emotional appeal may cause the child to respond in a larger visual sphere than larger, less important objects with the same contrast and color. Visual sphere should also be evaluated in relation to orientation in unknown and familiar surroundings because the ability to detect landmarks for orientation should be trained early. If standardized objects at high and low contrast (see Figure 1) are used for evaluation of the visual sphere, findings from different therapy and play situations are easy to compare.

**Contrast Sensitivity**

Contrast sensitivity is the ability to detect subtle differences in the luminance between adjacent surfaces. It is an
important visual skill because the typical daily environment is composed of objects with low-to-medium contrast rather than high contrast. Contrast sensitivity measurements are simple to administer. The Hiding Heidi Low Contrast Face Test (Precision Vision, 1995) allows assessment of low contrast vision as soon as the child can fixate on the picture of a face. By showing the low contrast pictures of a face at different distances, therapists can assess the visual sphere for low contrast information in communication. Starting at the age of 18 to 20 months, contrast sensitivity can be measured with optotype tests (see Figure 1). Children of this age give more accurate responses when the low contrast test uses 9.5M symbols (corresponding to 20/200 visual acuity at 1 meter) than when the high contrast visual acuity symbols of smaller sizes are shown because young children have little exposure to small high contrast details before they start looking at the texts in children’s books. If during the assessment the child has great difficulty fixating on the symbols, allowing the child to point with his or her own finger will help. To prevent smudging the surface of the test (which damages it), the child’s finger can be covered with tube gauze. Because the white tube gauze against the white surface of the test may make the finger invisible to the child, a piece of marking tape placed on the gauze on the tip of the finger will help the child locate the figure.

**Visual Field**

The visual field is the area that can be seen when a person is looking straight ahead. The visual field is approximately 180° in persons with normal vision. Visual field is measured through perimetry testing. A gross estimation of the size of the visual field can be obtained through confrontation testing. Visual field is difficult to measure before school age, yet knowing the size and quality of visual field helps determine the child’s ability to develop spatial concepts, orient to the environment, and communicate within a group of persons.

Difficulty accurately measuring the visual field in children is a result of how we look around to view objects. Visual attention is focused on the object that the gaze is fixated upon. If an object appears in the peripheral visual field, preattentional visual function makes the person aware of the object, and fixation is turned to the new object if it is interesting enough (Treisman, Cavanagh, Fischer, Ramachandran, & von der Heydt, 1990). Visual field is measured through confrontation testing by having the child fixate on a central target (a fixation stick or the face of the examiner) while moving targets into the peripheral field from behind the child. The border of the field is determined by noting how far forward the target must be moved before the child notices it. During measurement of the visual field, there is constant rivalry between the central target and the peripheral target appearing from behind. Often the central target predominates, even if vision in the peripheral field is normal. When examining children, it is better to use colorful balls that are rolled from behind or toys that are brought quietly into the peripheral visual field as targets than to use the white balls that are traditionally included in clinical vision examinations.

As previously mentioned, deficits in visual attention affect the use of visual fields. Neglect of one half of the visual space is easily recognized when the child appears unaware of one side of his or her body. If awareness of half of the visual field is diminished but not absent and there are motor deficits on the same side, differential diagnosis between visual field defect and attentional defect will require careful observation of visual behavior over repeated treatment sessions. If over a period of time the child demonstrates greater awareness of the neglected space, then the deficit was probably due to inattention. If unawareness of the body space continues, then the child may have either a visual field deficit or inattention or both.

Scotomas (blind spots or spotty field loss) within the visual field cannot be measured before the child can perform in clinical tests like Goldmann or Damato perimetry (Precision Vision, 1995). However, loss of function in central areas of the visual field can become apparent during observation of the child performing near-vision tasks. When small objects or pictures are consistently missed in a specific area, the child’s physician should be notified.

If the child has a very limited visual field, teaching the child how to scan the environment, in an organized and efficient way, should be initiated as soon as the child has some concept of visual space. The child will develop a better grasp of the world around him or her when exploration of the environment through visual scanning is immediately followed by exploration with the hands, feet, or face. The use of activities in which the child must locate a specific toy or object and then manipulate it in some manner can be used to reinforce vision with motor feedback.

**Visual Adaptation**

Visual adaptation is the ability of the eye to adapt to changes in lighting. Delayed visual adaptation can cause photophobia (greater than normal sensitivity to light) and difficulty seeing in semidark spaces where children sometimes play. Photophobia can be so great that the child’s eyes may turn under the eyelids and the child may refuse to use vision in normal room illumination. Sunglasses can also be used, even in places with indoor lighting, and should be tried whenever photophobia is suspected. Delayed adaptation to the dark can be diagnosed in play situations by having the child sort red discs from blue discs of the same size (Thornton, 1977). The test is now commercially available as the Precision Vision CONE Adaptation Test (Precision Vision, 1995) (see Figure 1).
Color Vision

Color vision is often impaired in children with low vision and therefore should be evaluated as soon as the child can perform in test situations. When the child is able to sort bright basic colors, color vision can be measured with commercially available sorting tests such as the Precision Vision PV-16 Color Vision Test (Precision Vision, 1995) (see Figure 1). The test manual describes several different play situations where the child can be trained to match caps of the same colors and then of similar colors. Although the axis of color deficiency is rarely well measured before a child is 5 years old, color confusion can be identified in children between 2 and 2 1/2 years of age. Evaluation of color vision is important because colors are critical to the recognition of objects. In children with cortical visual impairment, colors can be used as an effective coding system when forms cannot be recognized.

Accommodation

Accommodation is the ability to keep objects focused clearly on the retina by changing the refractive power of the lens. Accommodation may be impaired or even absent in children with visual impairments. In some children with spastic dystonia, accommodative spasms may be observed, during which the eyes are locked into near focus, causing distant objects to appear blurred. If the optic media are clear, accommodation can be measured during clinical examination by the physician. However, the infant or child must be motivated to maintain focus on a small object next to the retinoscope. By moving farther and closer, the examiner can detect whether the child's accommodation is changing accordingly. If the optic media are cloudy, the only possibility is to try different reading glasses in play situations and observe the child's responses. Reading lenses during the first few years of age are strong (5 to 10 diopters) because the focal distances that a child with visual impairment uses for learning are short. Frequently, vision improves markedly the first time a pair of plus-10 diopter reading glasses are tried. In other cases, the lenses must be tried on several occasions before the child shows a notable response in performance. Evaluation of accommodation and training with high-plus reading lenses is unfamiliar territory for many therapists, and close cooperation with the child's ophthalmologist or optometrist is needed to provide this aspect of treatment.

Oculomotor Deficits

In the United States, oculomotor deficits in children with severe motor problems will fall primarily in the specialty area of occupational therapists. Evaluation should include observation of the effects of different postures on oculomotor functions, eye–hand coordination, and the role of abnormal reflexes on the use of vision. The therapist's observations should be reported in detail to the physician so that the child can be in the optimal postural position during the physician's evaluation. The physician should be informed if the child cannot use vision and motor functions simultaneously (e.g., if the child must turn his or her eyes and head away before reaching for an object). Observation of the child's motor behavior is best documented on videotape, where it can be reviewed several times to decide if the irregularities in functions are related to inadequate planning and execution of movements or are related to something else, for example, to a change in the fixating eye when there is alternating strabismus. Development of eye–hand and eye–foot coordination may also be best evaluated with videotape documentation.

Response to Visual Stimulation

Visual stimulation has become a regular part of early intervention. The child's ability to benefit from different types of stimulation should be carefully evaluated. Visual stimulation must be clearly distinguished from visual noise. Impaired visual systems function best if visual information has good contrast and does not have too many details and if the child is given enough time for both observation and assimilation. Well-structured visual materials can be effectively used as a reward during motor training (see Figure 2). Too much visual information bombarding the child may be so chaotic and disturbing that the child avoids using vision. Visual stimulation can be combined with auditory and tactile stimulation. However, children with brain damage may have difficulties integrating information from several sensory modalities. With some imagination, visual stimulation can be combined with all kinds of activities, including feeding, dress-
ing, and grooming. Combining activities will assist the child in integrating visual clues with other simultaneous sensory input and motor functions. Children with severe hypotonia or spastic quadriplegia may be able to start using vision only in warm baths, where they do not need to use all their energy for gross motor functions. In these cases, visual stimulation and training is included in swimming and bathing. In some cases, what is sometimes called a ball room—a play area filled with plastic balls of different colors among which children can play—has a similar effect as warm water.

Teamwork in Delivery of Early Intervention Services

Because members of the habilitation team can learn much from each other's observations, good communication between the members is important. Communication is enhanced when the vocabularies of each specialty are clearly understood by all members of the team. The most positive environment is one in which team members are encouraged to ask each other, "What do you actually mean?" Observations of motor functions are easier to report if videotapes are made during therapy sessions and educational tasks. Most physicians do not know the daily problems encountered by the other team members as they work with the child. Frequent interaction between the physician and the other team members is important for discussing treatment strategies. As physicians gain more knowledge about the functional visual impairments experienced by children, communication between physicians and other team members is likely to improve. The American Academy of Ophthalmology has taken an important step toward further education in vision rehabilitation with the publication of its first low vision rehabilitation ophthalmology monograph (Fletcher, in press), which contains detailed information of all aspects of low vision services.

The functional aspects of vision become easier to understand and value if the members can participate in weekend gatherings and summer camps where children behave very differently than they do in medical offices and therapy sessions. Because vision is our most holistic sense, impairment of vision affects all aspects of a child's adaptation to the environment, including motor, cognitive, language, and emotional areas. Because of this importance, early intervention of the child with visual impairments should involve a holistic approach that addresses both the development of vision and the general development of the child.

References


