Sequential Levels in the Visual-Motor Development of a Child With Cerebral Palsy

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During the past decade, because of the growth of infant stimulation programs and the enactment of PL 94-142, the Education for All Handicapped Children Act, occupational therapists have become increasingly involved in the assessment and treatment of children with developmental disabilities (Anderson, 1986; Anderson & Anderson, 1986; Campbell, McInrey, & Cooper, 1984; Denton, 1986; Magill & Hurlburt, 1986; Sparling, Walker, & Singdahlsen, 1984). Approximately 80% of the children in this group show delayed and abnormal functional vision within the total pattern of motor dysfunction, but few studies have been reported concerning their unique needs, and research has been fragmented (Fieber & Robinson, 1974; Gates, 1985, Harley & Altmeyer, 1982, Jose, Smith, & Shane, 1980; Mayberry & Gilligan, 1985). These children differ from those with a primary condition of low vision or blindness, visual perception problems, or sensory-integrative deficits affecting their visual-vestibular postural mechanisms.

This report describes the literature review of visual-motor development in the normal infant, sug-
gests a sequential organization of this information into a useful assessment scale, and demonstrates the application of treatment approaches that integrate visual stimulation activities with developmentally appropriate postures and movements.

The subject of this case report is a 2-year-old boy with moderately severe cerebral palsy. He was born 12 weeks prematurely, weighing 2 lb 2 oz (see Figure 1). At the postnatal age of 4 months he was discharged from the hospital to his adoptive family, and by 7 months he was referred for a home occupational therapy program with a pediatrician's diagnosis of delayed psychomotor development, generalized spasticity, and suspected cortical blindness. Head control was poor, with no visual fixation or tracking, and his eyes were consistently in upward gaze, dominated by the strong asymmetrical extensor synergic posture of eyes, neck, trunk, and lower extremities (see Figures 2 and 3). Some of the initial goals were to normalize tone throughout the body, increase chin tuck and head control in midline, and stimulate functional vision.

After 1½ years of a home-based occupational therapy program involving parents, siblings, and home health aides in the neurodevelopmental treatment (NDT) approach, the subject had shown significant improvement in normalization of muscle tone, midline orientation, and head control, but visual function was still limited and inconsistent.

Traditional approaches to the study of vision have emphasized either the medical model of pathology concerned with visual acuity (distinguishing detail) or the educational model of cognitive processing concerned with visual perception (extracting information from visual stimulation). Very little information is found in the literature concerning the motor components of the visual action system, particularly the process of eye/hand linkage, which influences the development of both eye and hand function. An exception was Gesell's research at the Yale Clinic of Child Development and the research of those who continued his work (Gesell, 1949; Knobloch & Pasamanick, 1974; Ling, 1942). Gesell's involvement with optometrists like Skeffington and German led to new models of functional, developmental, and behavioral visual therapy (Wold, 1978).

Therapists working with children who have cerebral palsy have found developmental approaches to evaluation and treatment to be useful, especially for those with delayed and/or abnormal prehension patterns (Erhardt, 1982). Since all children, with or without disabilities, develop within the framework of predictable progressive stages, early reflexes and primitive movement patterns provide the foundation for more voluntary refined movements, and each step in the sequence of motor development is dependent on the integration of the preceding steps (Erhardt, Beatty, & Hertsgaard, 1981).

Assessment

The Erhardt Developmental Vision Assessment (EDVA) (Erhardt, 1986), which was used to evaluate this subject, was compiled from a group of references.
from a variety of professional disciplines, including medicine, education, child development, and developmental psychology. The assessment measures vision development from the fetal and natal levels to the 6-month level, when, according to the literature, primitive visual reflexes are integrated and essential eye movement components are nearly as functional as in the mature adult. Increased skills in localization (visual approach), fixation (visual grasp), ocular pursuit (visual manipulation), and gaze shift (visual release) is gained through experience and interweaving with the total cognitive and motor action system as the child grows older. Since the 6-month level can be considered a significant stage of maturity in visual-motor development, it can be used as an approximate norm for assessing older children (Erhardt, 1986). The assessment is organized into two main sections:

- A section of primarily involuntary visual patterns (reflexive), consisting of 3 clusters: Pupillary Reactions, Doll’s Eye Responses, and Eyelid Reflexes and
- A section of primarily voluntary eye movements (cognitively-directed) consisting of four clusters: Localization, Fixation, Ocular Pursuit, and Gaze Shift.

Implications of Delayed Visual Development

The subject’s first developmental vision assessment, at the age of 2 years, will be used for discussing the implications of delayed visual-motor development. Figure 4 illustrates the organization of the assessment as well as the score sheet summary. Details of pattern components, scoring, and developmental levels are illustrated by one of the subject’s protocol sheets (see Figure 5). The first section, primarily involuntary

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Figure 5
Localization (Visual Approach)

<table>
<thead>
<tr>
<th>Developmental Levels</th>
<th>Pattern Components</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RL</td>
</tr>
<tr>
<td>3 months</td>
<td>RL</td>
</tr>
<tr>
<td></td>
<td>Regards own hand spontaneously</td>
</tr>
<tr>
<td></td>
<td>Attention to moving targets at peak, especially rhythmical</td>
</tr>
<tr>
<td></td>
<td>Turns head and eyes toward side of sound, 18&quot; from ear</td>
</tr>
<tr>
<td></td>
<td>Swipes at localized target</td>
</tr>
<tr>
<td></td>
<td>Searches for areas of light</td>
</tr>
<tr>
<td></td>
<td>Recognizes family members up to 6' away (middle space) without voice</td>
</tr>
<tr>
<td></td>
<td>Direct regard and facial response to faces in optimal fields</td>
</tr>
<tr>
<td></td>
<td>Delayed midline regard to target brought from vertical upward (viewed at chest level)</td>
</tr>
<tr>
<td></td>
<td>Turns head and eyes to general direction of sound sources</td>
</tr>
<tr>
<td></td>
<td>Attracted by movement</td>
</tr>
<tr>
<td>2 months</td>
<td>RL</td>
</tr>
<tr>
<td></td>
<td>Head and eyes move together</td>
</tr>
<tr>
<td></td>
<td>Disregards target in midline</td>
</tr>
<tr>
<td></td>
<td>Fleeting regard of faces</td>
</tr>
<tr>
<td>1 month</td>
<td>RL</td>
</tr>
<tr>
<td></td>
<td>Opens eyes and attends to sound, but no head turning</td>
</tr>
<tr>
<td></td>
<td>Indifference to faces</td>
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<tr>
<td></td>
<td>Random eye movements, not together with head movements</td>
</tr>
<tr>
<td></td>
<td>Diffuse distractibility to targets in periphery</td>
</tr>
<tr>
<td>Natal</td>
<td>RL</td>
</tr>
<tr>
<td></td>
<td>Regards stationary dangling target at focal length of 8&quot;</td>
</tr>
<tr>
<td></td>
<td>Quiets when gazing toward light</td>
</tr>
<tr>
<td></td>
<td>Quiets watching bright moving target</td>
</tr>
<tr>
<td></td>
<td>May open mouth with effort to focus</td>
</tr>
</tbody>
</table>


This figure further develops part of cluster 2a of Figure 4.

The scoring symbols for the pattern components (in the small circles) and for the developmental levels (in the large circles) indicate present (+), emerging (±), absent (−), and transitional pattern replaced by a more mature pattern (++).

R = right; L = left.
Pattern components (small scoring circles) recommended for intervention are once again encircled (oval "circles").
visual patterns, consists of three clusters, which are discussed as follows:

Cluster 1a deals with the pupillary reactions of constriction and dilation, showing different responses to different degrees of light at different age levels (see Figure 4). The subject responded immediately to strong light such as a flashlight, but showed a very sluggish or no response to a penlite or other weaker light. Since the normal infant's eye adapts first and foremost to light, these reactions are vital for the activation of the entire visual system (deQuiros, 1978; Peiper, 1963)

Cluster 1b deals with Doll's Eye responses that involve head movements of rotation, flexion, and extension, as well as the involuntary eye movements which appear to be the exact opposite but are actually eyes lagging in moving with the head (see Figure 4). Although this reflex provides the important sensory experience of eyes separating from the head for more rapid and skilled function such as reading, it can interfere with the development of controlled eye/head movements if it is not integrated by 3 months. The subject showed beginning integration, that is, the eyes lagged slightly as the head was moved.

Cluster 1c includes several important eyelid reflexes, which further activate the visual system as the eyes respond to sound, touch, and movement as well as light (see Figure 4). The subject had no defensive blink to threat, not even to large targets that usually elicit a response when small ones do not.

The second section, primarily voluntary eye movements, consists of four clusters, which are discussed as follows:

Cluster 2a deals with localization, which presents the subject's scores at the natal, 1-, 2-, and 3-month levels (see Figure 5) The subject's developmental levels (the large scoring circles on the left) showed all patterns present (+) for the natal level and a mixture of some patterns achieved, some emerging, some absent (±) for the 1-, 2-, and 3-month levels.

For example, the subject still had some random, uncontrolled eye movements that were not always together with head movements (natal); he regarded an agitated target in line of vision only, that is, where he happened to be looking, but he wouldn't necessarily turn to it, and he had only a fleeting regard of faces (1 month); he turned his head and eyes to the general direction of the sound source, was attracted by movement, and was beginning to turn toward a target in the peripheral field, but he had delayed midline regard in central field (2 months); he was beginning to recognize family members in middle space, not only near space, but he did not actively search for them, and he did not look at his own hand spontaneously or reach toward objects (3 months).

Components that were encircled for intervention included the following: localization to diffused light, illuminated targets, focalized stationary lights, targets with sound properties, his own hand, targets in middle space (1-6 ft), and faces, as much as possible in midline and slightly below eye level, to help reduce asymmetry and encourage chin tuck.

Cluster 2b in the next section deals with fixation and demonstrates which stimuli are the most motivating at different age levels (e.g., various black and...
white patterns, large vs. small targets, targets in different focal lengths, and the competition between stationary and moving targets); this has implications for distractibility in the classroom (see Figure 4). The subject had difficulty with sustained fixation, since his eyes drifted away easily. He needed highly stimulating materials that were appropriate for the level of his visual development as well as for his age.

Cluster 2c deals with ocular pursuit and shows a developmental sequence that offers a convenient guide for presenting tracking activities (see Figure 4). It is much easier for the child to track at first horizontally from periphery to midline and back, then gradually pass midline, and finally throughout the 180 degree range. The midline jerk, interestingly, appears in normal visual development, not just in children with learning disabilities (Blackwell, Britz, & Rock, 1983; Gesell, 1949; Gilfoyle, 1981; Illingworth, 1971; Knickerbocker, 1980). The subject was able to track past midline, but in a series of jerky movements, losing the target frequently. Tracking activities needed to be done so slowly that the target was never lost.

The last cluster, 2d deals with gaze shift and explains why certain children have difficulty releasing gaze (usually needing to blink to do it) and are inaccurate when relocating, often overshooting the target (see Figure 4). Alternating glances between two targets in the same focal length gradually improve, but when a child tries to shift gaze from one focal length to another, the child loses his or her facility once again. The child needs to proceed through many developmental steps before being able to handle academic tasks such as reading, which involve skilled eye movements scanning a series of targets, and alternating glances from desk to board, which involve different focal lengths.

Figure 8
*Improved Head Control and Eye Contact With Sister*

Figure 9
*Subject Watching His Hand Contact Switch to Operate Fan*

When enormous amounts of energy are channeled into these motor components of vision, very little is left for the cognitive processing of the sensory input. In other words, higher-level cortical thinking is often suspended when normally automatic subcortical functions require voluntary attention.

**Treatment**

Intervention was designed to integrate the individualized visual stimulation activities into the subject's occupational therapy program. Goals were to do the following:

- Activate the visual action system by varying the lighting conditions, sometimes abruptly, during the therapy session, from very dim to very bright, to stimulate pupil adaptation.
- Stimulate defensive blink. (The subject's father noticed that he could get a blink when he moved his entire body toward the child. Thus, the activity was begun by moving large targets rapidly toward the child, stopping abruptly a few inches from his face, and gradually reducing the size of the targets.)
- Improve localization to faces by speaking the child's name, and waiting for his eyes and head to turn before continuing to speak; also, at other times, approaching without speaking, but smiling, and waiting for a facial or vocal response before speaking.
- Increase length of fixation by placing the subject's stander against a window, where staring at large targets in far space was easier than in near space. (The normal infant first immobilizes the eyes at 1 month by staring at surroundings. Awareness of sun move-
ment was important to avoid ultraviolet or infrared rays, which could damage the subject's eyes. Faces, which incorporate both sound and movement, were used to improve eye contact, as well as a mirror, put on the floor to get head control in prone [see Figure 6]. Sustained hand watching was also encouraged, initially by placing toys in the subject's hand since he did not not yet grasp independently [see Figure 7].

- Improve ocular pursuit while the subject is in various positions such as prone, supported sitting, and supported standing by encouraging the tracking of people walking slowly across the room. (Since the eyes act as the pilot mechanism for the head and the head, in turn, is the pilot mechanism for the body, visual stability and motility needed to be developed concurrently with those of the head and trunk [Harmon, 1958].)
- Improve gaze shift in the optimal focal length, and in such a way that stress and effort would be minimal, to reduce the obligatory blinking. (A mirror was used not only for reaching, touching, and pointing to body parts, but also for alternating glances between the therapist's image and the subject's own image.)

**Results**

The subject was evaluated 1 year later when he was 3 years old. The following changes were noted:

- More rapid pupillary reactions to light;
- A strong defensive blink in reaction to small as well as huge targets;
- Visual recognition of family members by face rather than just voice, indicated by a more sustained fixation, smiling, and vocalizing in response to another's soundless smile (see Figure 8);
- Spontaneous smile to mirror;
- Visual monitoring of right hand contacting target (see Figure 9);
- Attention to targets in middle space, up to 6 ft away, which resulted in the subject's ability to use a new gross motor skill, belly crawling, to follow directions such as, "crawl into your bedroom";
- Prompt midline regard with improved head control in prone, sitting, and supported standing positions (see Figure 10).

**Summary**

This case report has described an occupational therapy program for the treatment of a subject with visual-motor problems related to the total pattern of motor dysfunction in cerebral palsy. The intervention plan used visual stimulation activities that were developmentally and functionally appropriate and contributed to observable and measurable improvement within 1 year. Further research on this developmentally referenced instrument will include an inter-rater reliability study.

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**References**


