Article ▸ Visual Perceptual Evaluation in Early School Aged Children

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ABSTRACT

Visual Information Processing includes a multitude of skills that allow selection, analysis, and integration of information from the environment. For children, the development of these abilities is central for success with school, hobbies, and daily life. Detection of delays in younger children allows the opportunity for early intervention that can be critical during this period of rapid development. The State University of New York (SUNY) battery allows for evaluation of visual motor and visual spatial abilities in young children from the ages of two years old to nine years old. It is also an important option to consider for children with special needs who are unable to undergo standardized testing. Vision therapy is a recommended treatment for patients who display delays with any of these abilities. It may also be necessary to incorporate interdisciplinary management in the care of these children in order to ensure full-scope treatment of their delays. A case report will review the diagnosis and management of a four-year-old patient with special needs, visual motor skill delays, and visual spatial skill delays.

Keywords: bimanual integration, form matching and reproduction, visual information processing, visual motor hierarchy, visual motor skills, visual organization, visualized reversals, visual spatial skills

Background

Visual Information Processing (VIP) is a group of visual cognitive skills used to select, to analyze, and to manipulate data from the environment. These processing skills allow patients to organize and to interpret information while integrating the visual input with other senses and higher cognitive functions.[1]

A strong association is noted between VIP skills and the total academic achievement of the child. Bowan[2] states, "The purpose of vision is to guide and direct learning, and movement is its medium." Five percent of schoolchildren in America are diagnosed with a learning disability, yet a larger number of children with milder problems remain undiagnosed. Of the children who are diagnosed, twenty percent are reported to have VIP difficulties.[3] As primary care health providers, it is important to recognize early signs related to delays in the development of visual processing. These signs can be noted as early as the patient history portion of the eye exam. With these children, the parent's concerns may not seem to be visually related, so the practitioner must be aware of the symptoms caused by processing difficulties as well.[4] Below is a list of common concerns expressed by parents of children with VIP deficiencies.

- "She won second place in the Spelling Bee but regularly spells words wrong on paper."
- "He's a great kid, but if I ask him to do more than one thing at a time, he always forgets at least one of the tasks."
- "I've noticed she is very clumsy. She always trips over her toys and often runs into things."
- "He has very messy handwriting and does not stay in the lines of the paper."
- "The teacher says to have his eyes checked, but every time I take him, they say his vision is 20/20!"

There are multiple theories regarding the normal development and processing of a child. The first that will be reviewed states that the rate of development in children is not uniform throughout their childhood.[1] Gesell[5] depicted normal motor development of children from the ages of two to nine years old as a cyclical, spiral-shaped graph. He stated that these developmental stages unfolded naturally as a child ages, but in some children, there could be a difference between chronological age and developmental age. There is importance to the shape in which Gesell portrayed these stages. The shape of a cyclical spiral, with each spiral representing a stage of growth, represents the time it takes a child to complete a stage. The focus of the graph is the rapid development through stages that occurs earlier in life, which slows down with age. This idea is also represented by Scheiman and Rouse[6] with a graph that depicts younger children passing through stages of development more quickly than older children. For example, the year between the ages of three and four years old possesses much more significance on a child's development than the year between 13 and 14 years old. Hence, early diagnosis and intervention during the rapid development phase can help provide the child with the skills necessary to be successful in school and daily life.

Another important theory of vision development is that of Skeffington.[7] He explores the idea that vision is the emergent of separate functional processing systems. Skeffington introduced the Four Circles of Vision Development: Anti-Gravity, Centering Process, Identification, and Speech/Auditory. The concept of Anti-Gravity explores the ability to appreciate where one is in space with regard to the object in question. The question "Where am I?" is answered using the skills of proprioception, balance, and fine motor abilities. Next, the Centering Process attempts to localize the image

that is seen. The question of "Where is it?" is addressed by using vergence, stereopsis, and oculomotor skills. Third, Identification describes the ocular and mental processes involved in choosing one object out of a larger environment. The question "What is it?" is answered by using both accommodative and figure-ground abilities. Finally, the Speech/Auditory circle allows one to discuss the object of regard by using language, memory, and social relation skills.

The final theory to be addressed is that of Suchoff, the author of the SUNY battery. Suchoff[8] stated that "the primary purpose of vision in the human organism is the organization and manipulation of space," and therefore, "the development of visual perceptual skills is closely related to a child's motor development." The concept of the visual motor hierarchy becomes important in this theory. As a child grows older, they move from predominately using their motor system to complete tasks to predominately using their visual system instead. This change in performance is complete around the age of seven to eight years old. The three areas of development described by Suchoff are as follows:[8]

1. The Invariant: Understanding self as the point from which vision originates. This is known as the Zero Point or the Reference Point.
2. Bilaterality: The motor and cognitive awareness that one is a two-sided being with understanding of the difference between these two sides.
3. Spatial Organization and Manipulation: The ability to relate to an act within a variety of spatial experiences.

Visually based tasks require three steps: recognition, analysis, and manipulation of the information.[9] During a routine vision examination, optometrists mainly focus on the first step of recognition. For example, evaluation of refractive error, diagnosis of amblyopia, and assessment of vergence or accommodative deficiencies are addressed. The analysis and manipulation of visual information requires further assessment. Proper visual development in young children is vital for overall milestones regarding social, emotional, and cognitive growth.[10] With this age group, an optometrist should also consider the integration of the visual and motor systems. These skills can be noted while the child performs simple activities such as building blocks, catching a ball, or writing. However, in order to consider developmental processes when examining a child with developmental delays, analysis is warranted. This may be accomplished using the SUNY battery.

The SUNY battery evaluates the analysis and manipulation components of visual information processing by focusing on visual motor skills and visual spatial skills. Visual motor skills integrate visual, perceptual, and motor abilities and allow a child's eyes and hands to coordinate together efficiently. These skills are used for numerous daily tasks such as sports, puzzles, tying shoelaces, and learning to write. Signs and symptoms of delays in these abilities can include difficulty using utensils, difficulty copying from the board, poor organization of writing, poor spacing in number columns, worse written spelling than oral spelling, and poor writing posture.[1] Visual spatial skills form the ability to understand directional concepts and to organize spatial relations in the external environment. These skills are used for navigating and understanding directions, recognizing orientation of letters, and manipulating visual information. Children who have delays with visual spatial skills display signs and symptoms of poorly developed gross motor skills, difficulty with balance and coordination, confusion of right and left, letter reversals, inconsistent directional attack when reading, and difficulty crossing their midline. When a child who cannot participate in traditional perceptual evaluations presents with signs and symptoms related to visual motor/spatial skills delays, the SUNY battery should be considered. The SUNY battery is designed for children ages three to eight years old and can be a powerful tool in the evaluation of young children and those with developmental delays.

Table 1. Areas Assessed by the SUNY Gross Motor Battery

Areas Assessed	Evaluation
Body Knowledge and Control	Standing Angels in Snow Chalkboard Circles 3.3 Alternate Hop Incomplete Man
Bimanual Integration Form Matching/Reproduction Visual-Motor Hierarchy	Circus Puzzle Pegboard Test Winterhaven Copy Form
Visualized Reversals	Pegboard Test
Organization	Winterhaven Copy Form

The Battery

The SUNY battery consists of seven activities that can be used to assess six areas of visual spatial and visual motor skills. The first area of assessment is Body Knowledge and Control, or the understanding of the Invariant. The battery evaluates the patient's awareness of relative space and their body, the Zero Point or Reference Point, in space. Bimanual Integration is the patient's awareness of bilaterality and dominance. Next, Form Matching and Reproduction and Visualized Reversals evaluate the ability to organize and to manipulate space from one's own perspective and the ability to organize and to manipulate space from another viewpoint, respectively. Organization is the ability visually to plan out a task in a given space. Finally, Visual-Motor Hierarchy examines the need for the child to involve the body in a visual task. The SUNY Gross Motor Battery is appropriate for both preschool and early school-aged children, as well as children with special needs or cognitive delays. Table 1 summarizes each area assessed by the battery and the particular procedures used in each. Procedures, observations to be noted, and age equivalencies for each assessment are listed in the Appendix.

Treatment

Optometric management of deficits in visual information processing skills includes vision therapy programs.[11] During

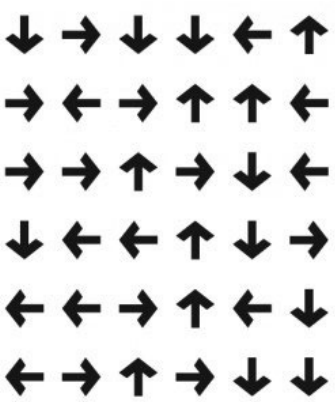

Figure 1. *Directional arrows*

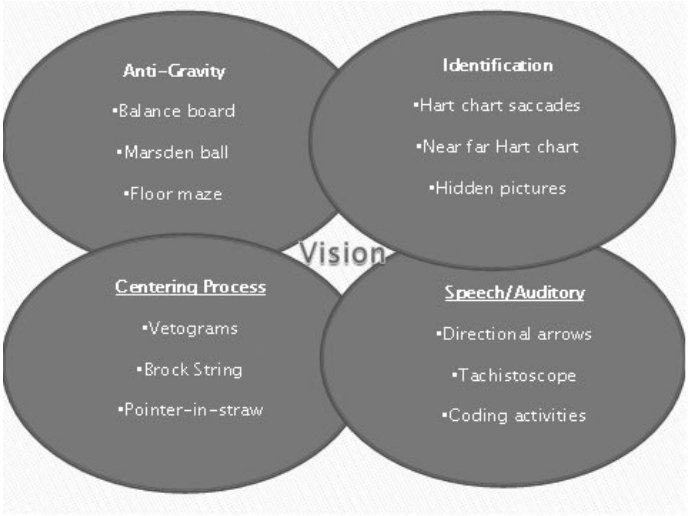

Figure 2. *Vision Therapy approach using Skeffington's Four Circles of Vision*

the initial vision examination, the patient's refractive error should be addressed, as well as other factors amenable to treatment, before beginning therapy. This may include specific types of lenses such as bifocals or the initiation of patching or pharmaceuticals for amblyopia as needed. Vision therapy typically focuses initially on visual efficiency skills. This is followed by the assessment and treatment of visual processing skills.

Vision therapy for the VIP abilities tested by the SUNY Gross Motor Battery begins with improvement of visual spatial skills followed by concentration on the visual motor skills. With visual spatial deficits, there are three aspects to consider: bilateral integration, laterality, and directionality.

Bilateral integration is the ability to use both sides of the body both separately and simultaneously. The child completes techniques that encourage both sides of their body to be used. This includes activities such as using alternating hands for beanbag toss, drawing and self-assessing chalkboard squares, performing Jumping Jacks, and adding a balance board to almost any activity.

Laterality is the ability to identify right and left on oneself. An example of an excellent therapy technique for laterality is the creation of a floor maze. This maze is created in real space using packing tape, with the doctor instructing the patient to walk through the maze while calling out which direction they are turning as they do so. Other activities include directional arrows (Figure 1) and Simon Says.

Directionality is the ability to interpret right and left on others or in external space. The Floor Maze and paper mazes can be used here by having the patient direct someone else or a character through the maze. Other activities include Thinking Directional Activities and Letter Finds. Thinking Directional Activities presents the patient with a map of a fictional town and asks the child visually to navigate their way through the map. Letter Finds presents the patient with similar letters (such as bdpq) in which each letter needs to be identified properly based on orientation.

Regarding visual motor skills, therapy activities are arranged in the following sequence: general hand-eye coordination, adequate visual-motor ergonomics, proficient visually guided fine-motor control, and capability of planning out visually guided motor actions.[1] General hand-eye coordination activities can include beanbag toss, Marsden ball tapping, and stick-in-straw or pegboard placement activities.[11] Visual-motor ergonomics focuses on ensuring that the patient has a proper pencil grip, uses their non-dominant hand for support, and maintains appropriate body posture and Harmon's distance. Harmon's distance is the length from the child's elbow to their middle knuckle and is recognized as the appropriate working distance.[12] Activities that concentrate on visually guided fine-motor skills include dot-to-dot figures, smiley face color-in worksheets, and directional mazes, where the child is instructed to complete the maze "without touching the walls." Finally, the ability to plan visually guided actions can be developed with parquetry blocks, pegboard pattern rotations, and many computer-based activities.

Visual processing delays can also addressed by approaching vision therapy with Skeffington's Four Circles of Vision Development in mind. By addressing the skills of each circle, the development of vision (the emergent) should be positively affected. Examples of activities that may be performed to focus specifically on each of the circles are presented in Figure 2.

It is important to keep in mind that these children may have other problems as well. Therefore, the final factor in management is the assessment of the need for any sort of interdisciplinary management. Most of these children are likely being followed by other professionals or should be referred to them for evaluation of therapy for their developmental delays. Attention deficiencies, behavioral issues, or learning disorders will require consultation with a developmental pediatrician or psychiatrist. In addition to developmental pediatricians and psychiatrists, a referral to an occupational or speech therapist may be appropriate. Occupational therapists excel in training fine and gross motor skills, proprioception, balance, and body awareness. They also focus in depth on abilities such as handwriting techniques. Speech therapy can assist with spoken or written language difficulties including the form, content, or use of functional language.[13] Speech therapists are also

Table 2. Results from the Initial Evaluation

Test	Results
Unaided visual acuities (Patient resistant to occlusion of either eye)	Distance: 20/25 OU Near: 20/30 OU (with Allen Figures)
Unaided cover test	Distance: orthophoria Near: 7-8 exophoria
Near point of convergence	To the nose
Stereopsis	200″on Lang
Retinoscopy	OD: +0.50-0.50x010 OS: +0.75-0.50x180
Slit lamp evaluation	Within normal limits, both eyes
Intraocular pressures	Within normal limits, both eyes
Dilated fundus evaluation	Within normal limits, both eyes

trained to help with cognitive-communication disorders that can include complexity in organizing, remembering, planning, and problem solving.

Case Presentation

A four-year-old Caucasian female presented to University Eye Center when an eye examination was recommended after completing a neuropsychological evaluation, where she was observed to be holding objects very close to her face. The parents reported that the child had unremarkable eye exams in the past at other clinics, with no history of glasses or ocular abnormalities. The mother reported that she had occasionally seen the child's left eye turning, especially in photos when she was younger, but the patient had no history of patching or surgical intervention. The father reported that the patient constantly misjudged depth perception. For example, if she were to see a stripe on the ground, she would raise her leg higher than necessary to move over it, as if she was climbing a stair. The patient's teachers had made similar observations about the child missing her steps.

The patient was a full-term baby born with hypoxic brain injury that resulted in post-natal seizures and damage to her motor system. Developmental delays were noted, with the child first walking at two years old and first talking at three years old. She was diagnosed with weak core strength and poor balance secondary to the hypoxic brain injury, as well as apraxia and expressive speech delay. She was in an integrated classroom setting and was receiving physical, occupational, and speech therapy multiple times per week. An initial vision examination was performed, with the results listed in Table 2.

Due to the chief complaints presented by the patient's parents and teachers, as well as the out-of-range finding detected upon near cover test, primary sensorimotor and oculomotor perceptual evaluations were completed at the patient's second examination. This testing focused on further assessment of binocular posture and visual developmental skills. The results of this examination are listed in Table 3.

Due to the patient's young age and developmental delays, a modified SUNY Gross Motor Battery was completed, consisting of Standing Angels in the Snow, Chalkboard Circles, 3:3 Alternate Hop, Circus Puzzle, and Winterhaven Copy Forms. Her results, as well as age equivalents, are found in Table 4:

Table 3. Results from the Second Evaluation

Test	Results
Unaided distance visual acuity (Lea symbols)	OD: 20/25 OS: 20/30 OU: 20/30
Unaided near visual acuity (Lea Symbols)	OU: 20/40
Unaided cover test	Distance: 20 pd intermittent left exotropia Near: 20 pd intermittent left exotropia
Stereopsis	0″ on Randot animals
Extraocular motility	Full, several fixation losses, motor overflow, and head movement
Pursuits	Sitting: Moderate head movement with several fixation losses, unable to complete two revolutions Standing: head movement more pronounced, body movement more pronounced

Table 4. Results from Modified SUNY Gross Motor Battery

Battery Item	Results	Age Equivalent
Standing Angels	• Execution of homologous movements • Monolateral movements difficult	4 years old
Chalkboard Circles	• Patient able to perform symmetrical circles for less than five revolutions • Unable to use both arms at the same time in phase	3-4 years old
3:3 Alternate Hop	• Patient unable to hop on either foot	3 years old
Circus Puzzle	• Right hand picks up puzzle piece on right and transfers to left • Pieces are placed with both hands • More than six form errors • Most form judgments completed on board • Patient forces pieces in	4-6 years old 2-3 years old 2-3 years old
Winterhaven Copy Forms	• Patient consistently used right hand for writing and left hand for support of paper • Only circle and cross reproduced	6 years old 2-3 years old

The evaluation noted an intermittent left exotropia and below-average oculomotor skills. Age equivalencies determined that the child's visual development system was delayed in body knowledge and control, form matching and reproduction, and visual-motor hierarchy. These were noted specifically during the 3:3 alternate hop and circus puzzle assessments. Vision therapy was a viable option for this patient, yet it was deferred due to limited time. After discussion with the parents, it was decided that the current therapies that the patient was attending were of higher priority at the time. Also considered was the beneficial influence on vision development that would accrue from the continuance of these other therapies. The parents were educated to allow outdoor playtime in order to emphasize core body strength and balance. They were also advised to focus on activities with motor manipulation of three-

Table 5. Results from the 6-Month Follow-Up

Test/Battery Item	Results
Unaided distance visual acuity (Lea symbols)	OD: 20/25 OS: 20/25+1 OU: 20/25
Unaided near visual acuity (Lea symbols)	OD: 20/20 OS: 20/20 OU: 20/20
Unaided cover test	Distance: 12 pd exophoria Near: 12 pd exophoria (prolonged occlusion) 9 positions of gaze (distance and near): 12 exophoria
Near point of convergence	Break at 5", recovery at 6"
Stereopsis	Positive RDS with Stereo Fly
Pursuits	Sitting: fixation losses, particularly on upgaze, with head movement overflow Standing: imbalance with patient shifting weight between feet; excessive head movement overflow; increased fixation losses than when compared to sitting
3:3 Alternate hop	Patient unable to perform activity without holding onto mother for balance. Right foot performance better than left foot performance using mother's support for balance. Age Equivalent: 3-4 years old

dimensional objects in order to encourage ocular alignment. Examples of home activities included building games such as block construction and craft activities such as bead stringing. The patient was scheduled for re-evaluation in six months.

At the six-month re-evaluation, the patient had begun kindergarten in a public school with an integrated classroom setting. She received physical therapy three times per week, occupational therapy two times per week, and speech therapy five times per week. The mother reported that the patient had been improving greatly in her current therapies since the last visit. Neither parent had noticed an eye turn in months, and no visual or ocular changes were reported. The examination results are found in Table 5.

The evaluation noted that visual acuities had improved, and sensorimotor and oculomotor follow-up testing demonstrated no strabismus, with only a moderate exophoric posture even upon prolonged occlusion. Although difficulty with ocular motility, motor skills, and balance remained, improvement was noted on overall motor ability. The patient, who was initially unable to hop on either foot, was able to complete the activity when assisted with balance. The parents were advised to continue current therapies and building and toy manipulation activities during playtime, and the patient was scheduled for a six-month return to clinic for re-evaluation.

Conclusion

Early evaluation should be considered when a detailed patient history uncovers symptoms suggestive of visual perceptual difficulties. Vision disorders and developmental delays can interfere with a child's ability to perform at full potential both in and out of school. As with many conditions and diagnoses, early intervention can allow for the best overall outcome. Visual motor abilities and visual spatial abilities can easily be assessed using the SUNY battery in young children and older children who cannot sit for standardized testing. If intervention is needed, vision therapy can provide treatment and improve skills for children who are diagnosed with these deficits. Interdisciplinary management is an important consideration when contemplating treatment as a whole. It can assist with tracking the global development of a child and simultaneously provide positive effects on the child's visual growth through alternate methods of developmental therapy. Through proper diagnosis and interdisciplinary treatment, health care professionals can provide these children with the skills that are necessary for a successful future.

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The online version of this article contains digital enhancements.

Appendix: Evaluations of the SUNY Gross Motor Battery

1. Standing Angel in Snow[1]
   1. **Procedure:** The patient stands straight in front of the doctor and is told that the only limb they should move is the one tapped by the doctor. If more than one limb is tapped, they should move both limbs simultaneously. The doctor goes on to conduct the evaluation in the following stages:
      - *Monolateral Movements:* Individually tap the right arm, right leg, left arm and left leg.
      - *Homologous Movements:* Tap both arms at once.
      - *Ipsilateral Movements:* Tap both the right arm and right leg, followed by the left arm and left leg.
      - *Contralateral Movements:* Tap the right arm and left leg followed by the left arm and right leg.

   2. **Observations:** Does the child look at the limb before moving it? Are the movements smooth or hesitant and jerky? Is there motor overflow of other limbs that should be still? Does the child need the instructions repeated? Does the child correct an error after one repetition?

   3. **Age Equivalencies:**
      Body Knowledge and Control
      3 = Movements are not related to touched body parts
      4 = Homologous movements are performed but monolateral movements are difficult
      5 = Homologous, monolateral, ipsilateral movements are performed; motor overflow present
      6 = Only contralateral movements produce much overflow or performance breakdown
      7 = Competent contralateral movement accompanied by minimal motor overflow and frequent "segmentation"
      8 = Child succeeds in all patterns without motor overflow

2. Chalkboard Circles[1]
   1. **Procedure:** This evaluation is represented in Figure 3. It can be completed on a large chalkboard or large dry erase board. The patient faces the board where the doctor has drawn an "x" in their line of sight. This is purely to give the child a focus point. Next they are given two pieces of chalk or two dry erase markers. Two types of circles are evaluated:
      - *Symmetrical Circles*. Here the child makes large circles on the board in which both their arms are moving towards their midline. After 5 revolutions, they are asked to switch directions so that both arms are moving away from their midline for five more circles.
      - *Reciprocal Circles*. Here one arm is moving away from their midline as the other moves towards it. If the patient is able to complete these for five revolutions, they are asked to switch the direction of the reciprocal circles for five more revolutions.

   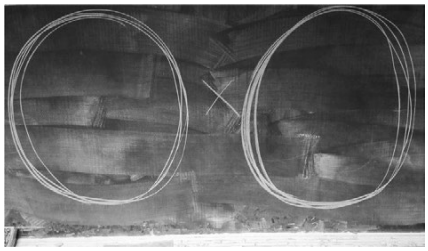

   Figure 3. *Chalkboard Circles*

   2. **Observations:** Are the arm movements synchronized? Is there hesitation before movement? Do they have a smooth transition in switching directions of circles? What is the overall quality of the drawn circle?

   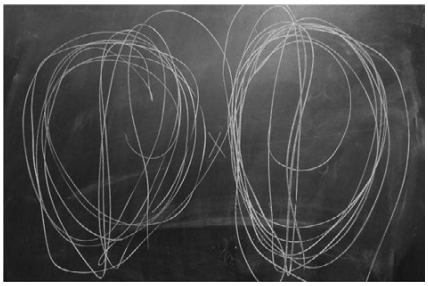

   Figure 4. *4-year-old results on Chalkboard Circles*

   3. **Age Equivalencies:**
      Body Knowledge and Control
      3 = Inability to use the two arms at the same time
      4 = Can perform symmetrical circles for less than five revolutions (Example: Figure 4.)
      5 = Symmetrical circles performed easily but on attempting reciprocal circle, patient reverts to symmetrical circles
      6 = Two or three reciprocal circles with phase differences or reverts to symmetrical circles
      7 = Reciprocal circles for 5+ revolutions with a phase difference only
      7 = Reciprocal circles cannot be reversed without reverting to symmetrical circles or a loss of phase
      8 = Reverses reciprocal circles on demand without phase loss

3. 3.3 Alternate Hop[1]
    1. **Procedure:** The patient is asked to hop in place three times on one foot and then three times on the other foot. Then they are asked to hop three times on their right foot followed by three times on their left foot and to continue in this cycle until he doctor says to stop. The doctor should demonstrate alternate hops to the child and offer their arm for support if balance difficultly is noted.
    2. **Observations:** Can the child maintain their balance? Are they able to hop on either leg? Are they able to alternate hop? Is there a smooth transition between altering feet or do they need to come to a complete stop before switching feet?
    3. **Age Equivalencies:**
    Body Knowledge and Control
    3 = Child unable to hop on either foot
    4 = Child hops on one foot but either more or less than three times
    5 = Child can hop on either foot but must make a complete stop when going from one side to the other
    6 = Decided pause in going from one side to the other and might add or lose a beat
    6 = Improves performance with support
    7 = Can do one or two cycles with a slight pause when switching
    8 = Smooth execution for 3 cycles without any pause

4. Incomplete Man[2]
    1. **Procedure:** A piece of paper with the Incomplete Man is presented to the child, centered at their midline, with a pencil. The doctor states "Someone started this picture but did not complete it. I want you to complete it."
    2. **Observations:** Does the patient use paper tilt or head/body tilt when completing the drawing? Is there a dominant hand chosen to draw with? Is the non writing hand used for support? Does the child have an appropriate pencil grip for their age? Which details of the drawing is paid attention to?
    3. **Age Equivalencies:**
    Body Knowledge and Control
    2.5 = Scribbling still strong. Absence of major details noted.
    3 = Scribbling gives way to controlled marking. Closure/encircling predominates. Child adds leg and eyes. Foot is drawn towards left.
    3.5= Fingers and ears added. Eyes are no longer a scribble.
    4 = Leg, foot, and arm added. All limbs are drawn too long. Foot is drawn towards left. Large open eye, body line and belly button often added.
    4.5 = Overlong hair, overlarge eyes, long arm and leg. Foot is drawn to right. Umbilicus may show up.
    5 = Completes body line. Hair usually continues around head. Ear is lopped down with no shape. Child may add five fingers.
    5.5 = Two-part neck treatment. Hair is shorter and neater.
    6 = Three-part neck treatment consisting of body line, neckline, and bow. Eyes are "dots". Legs correct. Doubling knot of tie is conflict. Double lines for legs and arms may begin.
    7 = Arm, hair length and placement improving. Tie is correct. Sees shape of ear. Uses eraser; self appraisal.
    8 = eyes more oval and have increased expression.
    9 = Eyes may have pupils, eyebrows, and eyelashes. Crossed eyes may be shown.
    10 = Lines less heavy, increased accuracy and delicacy of treatment of most parts.

5. Circus Puzzle[1,3]
    1. **Procedure:** The puzzle is placed so that its center is right at the center of the desk. The pieces are removed while the child watches and placed flat on the desk. The patient's body midline should also be aligned with the center of the puzzle. The pieces are arranged identical to Figure 5 to ensure that the child must cross their midline to retrieve and place them in the proper location. On the right side, place the Trapeze Man, Trapeze Lady, Green Clown, Seal, Clown with White Collar, and Lady on White House. On the left side, place the Rope Climber, Bar Bell Lifter, Lady and White Dog, Man and Two White Dogs, Elephant, and Lady and Bear.

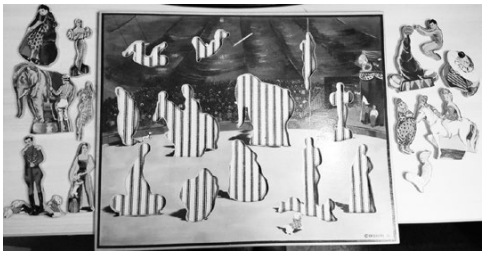

Figure 5. *Circus Puzzle piece arrangement at beginning of evaluation*

    2. **Observations:** Does the child use one hand or two hands for picking and placing the pieces? Is the placement of each piece visually guided or is the child using a trial/error technique? How many errors are made? What type of errors is made? Is the any head or body tilt?

3. **Age Equivalencies:**

Bimanual Integration

3-4 = Uses one hand only for pick and placement; does not use other hand for any support.
3-4 = Body tilt toward the side where the piece is being placed
4-6 = Right hand picks pieces on right, left hand picks pieces on left
4-6 = Pieces are placed with both hands
6-7 = Right hand picks pieces on right and transfers to left for placement on left. Left hand picks pieces on left.
7-8 = Consistently uses one hand for picking and one hand for placing.
7-8 = Consistently uses one hand for placing but pieces on right are picked by right hand and pieces on left are picked by left hand.
7-8= Pieces on left picked and placed by left hand; pieces on right picked and placed by right hand.
7-8= Picking and placing with one hand only; crosses midline easily.

Form Matching

A form error is made when the child is unable to fit a piece into the proper place. A false start is noted when the child puts the piece in the wrong place but then corrects the mistake.

2-3 = More than six form errors and gives up
3-4 = Six form errors
5 = Two to three form errors
5 = More than two false starts
5-6 = Two or less form errors and two or less false starts
6 = No form errors and two or less false starts

Visual motor Hierarchy

2-3 = Most form judgments of pieces are done on board
2-3 = Child attempts to force pieces in
4-5 = More accurate orientation judgments are mad before the piece contacts the board
5 = Chooses correct place for piece but may have to force it in
6 = All pieces correctly oriented before board contact

6. Pegboard Test[1]

1. **Procedure:** The doctor and patient sit across from each other with two peg board vertically lined up. The center of the patients' pegboard should be aligned with the patients' midline. The child closes their eyes and shakes the pegs in their hands while the doctor produces each pattern. Initially, the child is asked to recreate the exact pattern the doctor makes on their board. This procedure is repeated for all five models (Figures 6–10). The doctor should alternate the side of the board on which they produce the example pattern.

   The second phase is conducted in exactly the same manner except that the patient is asked produce the pattern as a mirror image. This is explained by referring to Pattern 1 and stating: "Let's make believe that this is a flag on a flag pole. Now I want you to make yours so that the flag flies the other way – the opposite way. Remember, I don't want you to make it upside-down, just opposite." Examples of the patterns are shown on Figure 6 and Figure 7.
2. **Observations:** Does the child use one hand or both hands for the activity? What is their fine motor ability? Is there any motor overflow or torsion of the head or body while recreating the patterns? Does the child use a specific directional attack? Do they easily cross their midline?

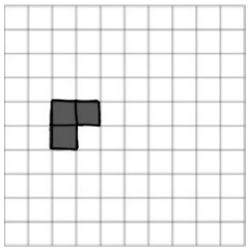

Figure 6. *Pegboard Form Reproduction Pattern 1*

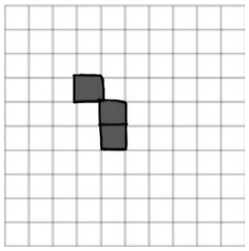

Figure 7. *Pegboard Form Reproduction Pattern 2*

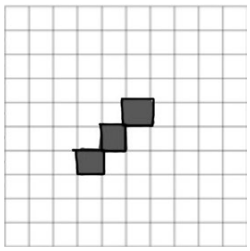

Figure 8. *Pegboard Form Reproduction Pattern 3*

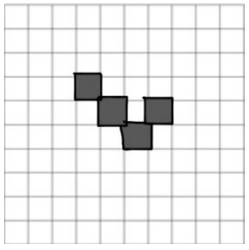

Figure 9. *Pegboard Form Reproduction Pattern 4*

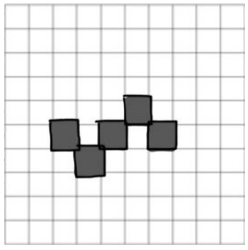

Figure 10. *Pegboard Form Reproduction Pattern 5*

3. **Age Equivalencies:**

Bimanual Integration

2-3 = Hold and places pegs with one hand only
2-3 = Puts pegs on table and picks and places them there
3-4 = Some use of both hands but reverts o use of one hand and body tilt as patterns become more complex
5-6 = Use of right hand and left hand equally in placement and holding of pegs. Hand used for placement is determined by location of the pattern on the board.
6-7 = One hand holds and the other hand places but reverses hands and patterns become more complex.
8 = Consistency of hold and placement throughout the test
9 = Holding and placing pieces with one hand without body tilt and fine motor clumsiness

Form Reproduction

2-3 = No patterns are reproduced
3-4 =Patterns 1 and 2 are reproduced
3-4 = Spontaneous lateral reversal of pattern 1 or 2
5-6 = Patterns 1 – 3 are reproduced
5-6 = Oblique elements or patterns 4 and 5 are verticalized or horizontalized
7 = All patterns reproduced but errors made and corrected on one or two patterns
8 = All patterns are reproduced without error

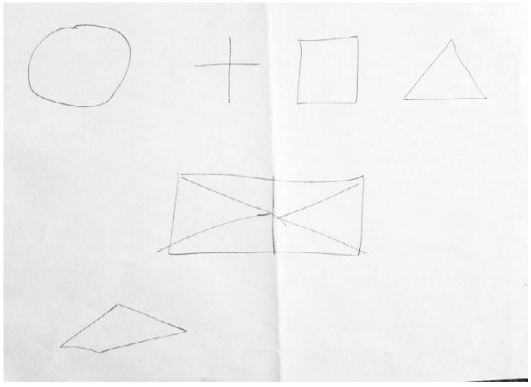

Figure 11. *8-year-old results on Winterhaven Copy Form*

Visual motor Hierarchy

2-3 = Child is unrelated to the task (pegs scattered all over board)
3-4 = "Central to Peripheral attack" (peg forming junction or center first and other pegs placed in proximity to it)
5 = No central to peripheral attack but frequent body/head/board tilt
7 = Body/head/board tilt on patterns 4 and 5 only
8 = All patterns are reproduced without body/head/board tilt

Visualized Reversals

2-4 = Not able to reverse any patterns
5 = Pattern 1 reversed
5 = Patterns 1 and 2 reversed
6 = Patterns 1 – 3 reversed
7 = Major part of pattern 4 reversed but oblique tail is usually either improperly reversed or is reproduced with a loss of obliquity
8 = Patterns 1 – 4 reversed
9 = All patterns reversed

7. Winterhaven Copy Forms[2]

1. **Procedure:** The patient sits across from the doctor with a piece of 8"x11" white, unlined paper placed horizontally centered at their midline. The doctor first presents all seven figures to the patient and makes them aware that they will be drawing all these shapes on the given paper. Then each geometric figure is individually presented so that the orientation is correct to the child and the patient is to copy it exactly.
2. **Observations:** What is the size of each figure? Is there organization in the placement of the figures? Does the child use a consistent dominant hand to write with? What is the non-writing hand used for? Is there an age appropriate pencil grip? Is there any paper tilt of head/body torsion while drawing?
3. **Age Equivalencies:**

Bimanual Integration

3 = Child writes with either hand and may switch hands when writing
4 = No consistent hand preference but does not switch hands while executing a particular figure
5 = Consistent use of one hand for writing but the other hand provides no support in holding or orienting paper
6 = Non-writing hand provides some degrees of support and orientation of paper
7-8 = Writing hand is free to draw with paper fully supported by non-writing hand (Example: Figure 11.)

Form Reproduction

2 = Circular or vertical scribbles
3 = Circle and cross are reproduced
4 = Circle, cross and square are completed
5 = Vertical distortion of triangle
5 = Segmentation of rectangle with accurate product resulting
6 = Circle, cross, square, triangle and rectangle show accurate proportioning o models; segmentation may be evident in the rectangle
7 = No segmentation of rectangle and slight distortion of the diamonds
8 = All figures accurately drawn

Organization

2-3 = Little organization and figures might be superimposed on one another
3-4 = Random placement predominates
4-5 = Circle centrally placed on paper with other figures surrounding it
5 = Inconsistent vertical or horizontal arrangement (2-3 arranged vertically or horizontally)
6 = More consistent vertical or horizontal placement (4-6 figures arranged vertically or horizontally)
7 = Vertical or horizontal placement only

Visual Motor Hierarchy

2-4 = Much of body involved in task
2 = Trunk involved in production of circle
4 = Heat movement with total arm movement
5 = Tongue or mouth support
5-6 = Tilt of body or paper when reproducing oblique lines
7 = Tilting is far less pronounced with only a slight head tilt present
8 = Only the patients eyes and hands are actively involved in the task

Sources

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2. Handbook of Diagnostic Tests for the Developmental Optometrist by Raymond Lowry. Available online at the Optometric Extension Program Foundation. http://bit.ly/2JOiOy4
3. Circus Puzzle. Available online at the Optometric Extension Program Foundation. http://bit.ly/2JRncfu