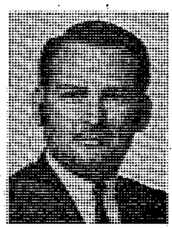
Motor planning and developmental apraxia

ARTHUR S. SEIDERMAN, O.D., F.A.A.O.

ABSTRACT

This paper is a discussion of developmental apraxia, which is characterized by a deficiency in the ability to motor plan. A review of this type of perceptual-motor dysfunction is presented along with its associated syndrome. Several case studies are presented to illustrate the theoretical discussion.



ARTHUR S. SEIDERMAN

ABOUT OUR AUTHOR

Dr. Seiderman received his A.B. degree from West Virginia Wesleyan College in 1959 and his O.D. degree from the Pennsylvania College of Optometry in 1963. He has taken post-graduate courses at the University of Vienna (Austria). Presently, he is studying toward a Master of Arts degree in child development at Fairleigh Dickinson University. Dr. Seiderman is a Fellow of the American Academy of Optometry and a member of the American Medical Society of Vienna. He has been a guest speaker and lecturer on numerous occasions.

Introduction

The detection of pathology and the correction of refractive errors are basic optometric procedures whether or not a child has a learning disability. Customarily these conditions do not present a problem to the optometrist who is treating a primary grade child with a learning disability or a perceptual lag. Of greater significance are poor ocular pursuits, rotations and saccadics, for these deficiencies in fine motor development may be a part of a more generalized apraxia. In treating these children, the optometrist must be cognizant of the normal ontogenetic sequence and therefore first develop gross motor and motor planning skills. Gesell (1949) states that "during the first decade of life, in particular, the components of the entire visual-motor system undergo ceaseless organization and reorganization, adapting not only to cultural demands, but even more to the structural changes within the organism itself. Very early the fundamental postural patterns (such as sitting, creeping, standing, walking, running, jumping, etc.) must be combined with increasingly refined eye-hand coordinations, mediated by the accessory musculature. Even the pupillary reflexes and the accommodation-convergence response of the intrinsic muscles must be brought into adaptive relation with the reflex and voluntary reactions of the extrinsic muscles which result in fixation, convergence and divergence, and pursuit and compensatory eye movements. Any ontogenetic interpretation of child vision, therefore, must take into systematic account the growth of the motor patterns of a total action system."[1]

Birch (1962) states that one can postulate that reading disability may stem from the inadequate development of appropriate hierarchical organization of sensory systems and so, at least in part, be the product of the failure of visual system hierarchical dominance.[2] Therefore, it is important for the optometrist to understand why a breakdown at more primitive levels affects both intersensory development as well as the hierarchical shift to visual dominance. If the organization of directed movement is dependent upon the integration of the sensory modalities, then it is by testing these modalities and their intersensory relationships that one may measure an individual's perceptual development. This is done to determine whether an orderly developmental shift has in fact taken place in a particular individual to the extent that he may effectively respond to instruction in the classroom.[3]

This paper provides a detailed account of just such a lag in motor development. With improved understanding of the development and age-expecteds in the various sensory and motor areas, the optometrist is able to deal more effectively with the problems of visual motor development, visual perception and visual synthesis.

In the various written accounts of human learning during infancy and early childhood by Jean Piaget, Arnold Gesell, Edith Cobb, Lois Barclay Murphy, Maria Montessori, Gordon Allport and other researchers, the acquisition of motor skills is seen as a crucial ingredient in the young child's understanding of an adjustment to the world of persons, things and ideas.[4] The inherent motility of the human organism and the behavioral changes that accrue from sensorimotor activity offer observable and predictable evidence of the basic role of movement in learning. The young child's movements are his first learnings, his first attempts to organize his own world on his own terms. The development of these general movement patterns yields to the development of more specific movement patterns, with unstructured movements becoming coordinated and random movements becoming purposeful and efficient. Gesell notes that a four-year old enjoys activities requiring balance, a five-year old skips alternately, and a six-year old bounces a ball. At five years of age gross motor activity is well developed.[5] His ability to integrate the two halves of the body is put together in much of his behavior. The child's progress will always depend upon the maturity of his nervous system.

Concomitant with the development of motor patterns in the child, but beginning later, is the development of perceptual organization. Because of its earlier beginning, the motor system has developed a certain body of information before the perceptual system begins its course of development. The motor system is not complete in its development, but an initial body of information has begun to build up. The child manipulates an object manually while he is observing the perceptual data and the changes in the perceptual data which he is receiving,[6] e.g., the child likes to take things apart to see how they work. Through this combined motor and perceptual exploration, perceptual data are matched to motor data so that perceptual information and motor information come to mean the same thing. It is essential that such perceptual motor matching take place. If it does not, or if it is restricted in extent, the child comes to live in two worlds—a motor world and a perceptual world. Since these two worlds may not be giving him identical information, he may be confused by the two types of activity and the different picture of the outside world presented to him. Since the motor information originated first, it is necessary that the perceptual data be matched to the motor data, not the opposite.

Interrelationships

Motor performance is closely associated with perception, which in turn is strongly related to purposeful motor activity. Any treatment planned to influence motor function cannot avoid affecting perceptual processes. Thus, the interrelation of perception and motion is especially critical when treatment is designed to enhance central nervous system integration. An individual must be able to interact with objects and act upon them in a skilled manner. This ability is termed "praxis" or motor planning. If a human being cannot perform purposeful acts, in the sense that a predetermined goal can be reached, all of the muscular strength and integration of upper motor neuron function will be to little avail.[7] In order to respond to the environment purposefully and motor plan effectively in relation to it, one must first be able to interpret it. Interpretation is dependent upon a sequence of events. The sensory receptors must be stimulated, followed by receipt of the resultant nerve impulses by the central nervous system. Comprehension of the sensory messages must follow. This can occur on either the conscious or sub-conscious level. Processing, organizing, and interpreting sensory information is the essence of perception. For example, in figure ground relationships, the child must be able to process, organize, and interpret the visual information in such a way that the figure stands out from the background. Perception is often followed by a motor act in response to that perceived. Development of perceptual abilities is further dependent upon obtaining some sensory feedback from the motor act which was elicited by the perceptual process. The feedback enables the organism to check the accuracy of the perception as well as the effectiveness of the motor response, e.g., in bouncing a ball to a given sequence, such as four times with the left hand and two times with the right hand. The child may bounce the ball 4-2-4-3 and say, "Whoops!," when making the error. This is the feedback necessary to check the accuracy of the motor response.

The brain, under normal circumstances, is an organizing system. When it is unsuccessful in accomplishing its integrative task, the behavior being directed by the brain fails to fall within "normal" expectations. For example, distractibility, one of the chief characteristics of children with central nervous disorders, is revealed as an inability of the individual to direct his attention to stimuli which are immediately significant to his adjustment. That is, he is unable to adapt negatively to unessential stimuli. The attention span of these children is relatively short. This behavior when observed by educators is not to be interpreted as willed misbehavior, but may, when adequate diagnosis is at hand, be understood as an undetermined, but evident, lack of that cortical control which permits prolonged attention to the task and negative adaptation to the unessential.[8] Man has five times as many nerve fibers carrying information about the environment into his central nervous system as he has nerve fibers for executing directions to his body to act on the world in which he lives. It is the task of the central nervous system to filter, organize and integrate the mass of sensory information so that it might be used for the development and execution of the brain's functions.[9] One of these functions is learning.

Motor Planning

Intersensory integration has been found to be deficient in brain damaged individuals (Birch and Belmont, 1965; Birch and Lefford, 1963). The organizing of cross-modality sensory information provides one of the most basic treatment principles. It is essential to the development of perception and probably contributes to the emergence of the capacity for abstract reasoning. The advantage in controlling sensory input through natural purposeful activity lies in the relatedness of the sensory input to the motor output. A goal-directed action automatically involves intersensory integration and provides an opportunity for feedback and centrifugal influence. Sensation advances into perception when it acquires meaning in terms of the relationship between the perceived and the perceiver. Random, poorly planned diffuse action typical of some children with perceptual-motor deficiencies has poor organizing influence compared to that of the normal child. Planned motor action is distinguished from habitual or automatic movement in that it requires the focus of attention for implementation. The process of focusing attention and exerting or expanding the effort necessary in accomplishing a challenging task imposes considerable integration of the sensory input to the central nervous system. Motor planning represents the highest kind of motor action requiring involvement of neurons of the motor cortex. As we ascend toward the cortex in the nervous system, the action becomes less organized, less automatic and more complex. Conversely, dissolution involves more organized, more automatic and less complex action—at a lower neural level. It seems possible that the demand of planned movement would influence the neural processes necessary for these convergent neurons to act as integrators. In addition to involving multisensory integration, it seems likely that the planning process would involve inhibitory unwanted responses and hence either depress or augment sensory input. It would also appear to provide a major source of control of sensory input. Any movement that requires that a child plan his movements carefully will probably enhance central nervous system integration in the manner just described. The more highly adaptive equilibrium responses are elicited by all activities making demands upon the child's ability to balance. Balancing activities serve the proper integration of postural reflexes; also, they provide one of the most forthright combinations stimulating the vestibular, as well as the somatosensory and visual systems. An adaptive response to that stimulation is required. The emphasis placed on sensorimotor function as a foundation for the development of perception and learning needs to be kept in proper focus. While sensory integrative processes serve an important role, the influence is limited. Where there is dysfunction in these integrative processes, remedial treatment can make a considerable difference in the maturational process, but in a child with normal sensorimotor development, the same procedure will probably not result in substantial gain in cognitive development.

Definition

Because a deficiency in the ability to motor plan is the primary characteristic of one of the categories of perceptual-motor dysfunction, it is suggested that it be called "apraxia" or "developmental apraxia."[10] These children are often referred to as being "clumsy." It has been considered a disorder of skilled motor function because it is this disability which is the inadequate but observable response to what is essentially a deficit in integration of certain types of tactile and to a lesser degree kinesthetic stimuli. Even that aspect can be easily overlooked, for clinical experience has demonstrated that a child can be rather severely apraxic, and, especially, if he has relatively well integrated upper motor neuron functions, perform the gross motor activities, such as walking, sitting and simple grasp, with apparent ease and effectiveness. But, when faced with an unfamiliar task he will either be unable to perform it, have difficulty in motor planning resulting in clumsiness, or will avoid the task. Even though he may be able to perform a task automatically or involuntarily, he may not be able to plan and perform the same task; e.g., buttoning a coat. While his major perceptual deficiency lies quite clearly in tactile functions, this is generally accompanied by weaknesses in the body schema area. The close relationships between deficits in motor planning and tactile perception suggests the primacy of tactile functions in the maturation process. Further evidence suggesting the primacy of tactile functions in early CNS integration is that the tracts of the nervous system carrying tactile stimuli are among the first to myelinate. The development of the central nervous system processes of organizing, inhibiting and augmenting tactile impulses in association with meaningful experiences must precede the ability to perform skilled motor tasks. Emphasis is placed on the word "precede" for concomitant tactile perception during a motor task is not a sufficient basis for motor planning. The continuous flow of tactile sensations, if meaningful, lay down in the brain the body scheme upon which all future motor planning is based. Although apraxic and agnosic disorders are known in children with cerebral palsy, it is not so widely recognized that similar disorders can occur as isolated disabilities without other signs of neurological disturbances.[11]

All motor acts except the more purely reflex, had to be motor planned at one time in each of our lives. Walking had to be planned, but once well learned it could be accomplished fairly automatically without further planning. With impaired ability to interpret the spatial qualities of tactile stimuli, the body scheme fails to mature and, consequently motor planning is difficult. To evaluate the presence of disorders of praxis requires tests of tactile perception, kinesthesis and motor planning. A simple but effective test of motor planning is asking the child to assume different postures demonstrated by the examiner. In studies conducted by Ayres, the clearest difference between the factorial structure of the scores from the normal children of this study[12] and on a group with dysfunction is a failure for the dimensions of praxis and form and space perception to appear as separate factors in the normal group. The tactile-motor planning alliance appearing so clearly in subjects with deficits in these domains is essentially unreflected in the intercorrelation of scores from the normal children. A pattern of low scores on tests of motor planning and tactile perception, then, suggests a developmental deviation best identified as dyspraxia.

Principle of Treatment

The basic principle of treatment is the enhancement of tactile and kinesthetic discrimination through control of sensory input followed by the demands of a purposeful skilled motor task. The motor act must be purposeful in order to require planning and to provide feedback necessary to inform the CNS whether or not the interpretation of the stimuli and motor directions were appropriate. Hopefully, this process enhances the development and function of the integrating mechanism.

Developmental Apraxia Syndrome

Walton, Ellis and Court reported on five "clumsy" children whom they observed for five years.[11a] Their purpose was to call attention to a syndrome of clumsiness due to developmental apraxia and agnosia. The main features of the syndrome included: severe clumsiness, defective recognition of nature and significance of tactile stimuli. There was awkwardness in dressing, feeding, walking and great difficulty in writing and drawing and even copying. No defect in the pyramidal, extrapyramidal or cerebellar pathways could be detected. It is of particular interest to note that two of the five children had been diagnosed as having a mental defect by competent pediatricians or neurologists. The parents were informed that their child was mentally backward. Intelligence tests showed that all children were of normal intelligence, as judged by verbal tests alone, while one was above average. In each child there was a marked discrepancy between verbal scores and the performance scores of the WISC, as shown below.

Verbal I.Q. (WISC)	Performance I.Q.	Previous diagnosis of mental backwardness
137	97	+
113	86	
99	65	
105	82	+
87	44	

Three of the five children also had defective articulation. These occurred without any underlying weakness, spasticity or incoordination of the articulatory muscles, which could be used involuntarily. This defect was attributed to the articulatory component of their more generalized apraxia. There is no evidence that in these children the deficit is a simple abnormality of maturation which is corrected with the passage of time. These disorders have persisted over several years of observation and have not been corrected by normal maturation processes, although they have been successfully modified by means of training.

In 1937, over thirty years ago, Orton recognized this kind of clumsiness and ascribed it to apraxia. He commented that the inaptitude of motor activity often involved movements of the body as a whole including such factors as balance, gait and not merely manual dexterity.[13] He also found that gross movements of the body in

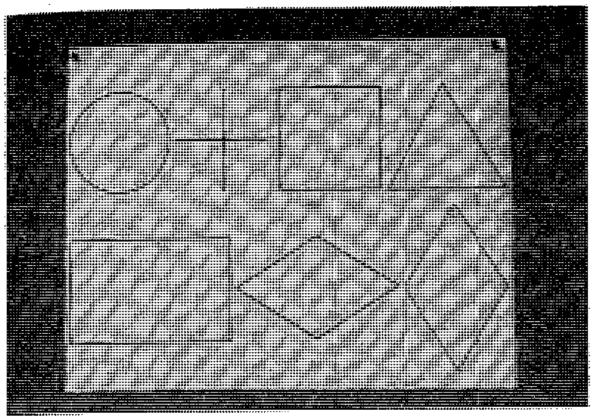


Fig. 1. Visual Copy Form Test—Sample Layout

walking, running, and jumping were poorly executed. Orton also noted that a feeling of inferiority seemed unavoidable in these apraxic children, especially when they reached the age of active physical competition where their limitations were exploited. Doll (1951), too, had probably observed apraxic children when he described a syndrome of neuro-muscular impairment other than typical cerebral palsy which was not easy to recognize.[14]

Case Studies

There are many factors involved in developmental apraxia. To illustrate some of the points previously discussed, I have chosen three children who are experiencing learning difficulties. Having evaluated these children my diagnosis is developmental apraxia. Their case histories and my clinical findings are as follows:

Subject #1 is J.K., a male, age six years, ten months, who was in a class for the neurologically impaired. He was examined and tested on March 22, 1969. The prenatal and perinatal histories were normal. He was reported to have been a colicky baby. The motor milestones were unremarkable. J.K. first talked at age 20 months, a little late. His articulation was slow in developing and is still poor. His general motor development may be described as "clumsy." There has apparently been at least some delay in his fine motor development.

A visual analysis revealed no evidence of

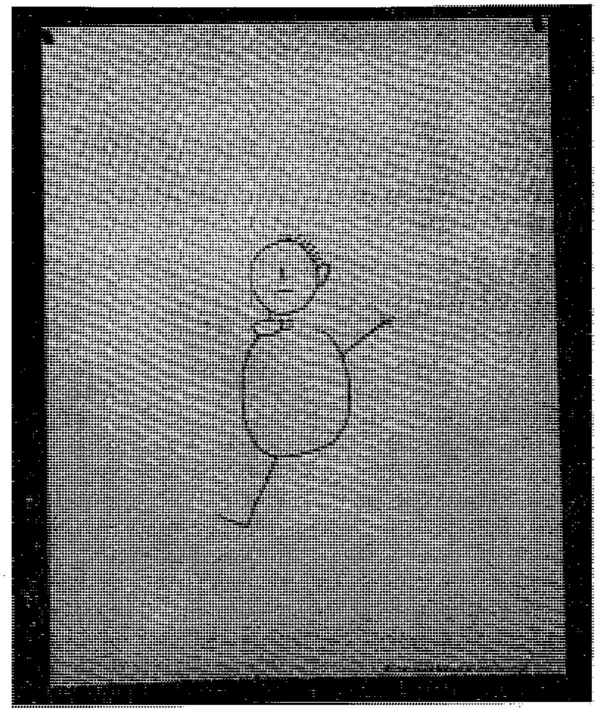


Fig. 2. Incomplete Man Test—Sample

pathology in either eye. Tests to establish the level of binocular coordination showed a tendency for the eyes to diverge both at distance and at near.

The Metropolitan Achievement Test, Primary I Battery, FormB,[15] was administered to determine the extent of his picture vocabulary and arithmetic concepts and skills. Word Knowledge showed mostly guessing, using initial consonant sounds. Arithmetic concepts and skills were equivalent to grade three.

The Roswell-Chall Reading Diagnostic Test[16] indicated that J.K. knew letter names and consonant and short vowel sounds. He could not blend short vowel words such as *rim, nap, sip,* etc.

Results from previous testing showed the following scores on the WISC.[17]

Verbal I.Q.	149
Performance I.Q.	86
Full Scale I.Q.	121

A developmental and perceptual evaluation was performed and the following are some of the more significant findings. The visual-perceptual span, using three digits at .1 seconds with a tachistoscope, place

Fig. 3. Visual Copy Form Test—J.K.

J.K. in the lower five percent of grade one norms.[18] This indicates a lag in visual processing. He scored age seven years, six months on the Digit Span Test of the WISC.[17a] He could repeat six digits forward, while repeating only two digits backward. This discrepancy suggests excessive rigidity in thinking, or more seriously, a tendency to fragmentize under pressure. J.K. could not conceptualize the Roswell-Chall Auditory Blending Test.[19] He also had difficulty conceptualizing the spacing of the dots on the Birch Auditory Visual Patterns,[20] indicating a lag in intersensory development. On the Block Design Test of the WISC,[17b] he scored equivalent to seven years, two months. He recognized linear conservation and reversibility on a Piaget Protocol,[21] which was good.

The Geometric Copy Form Test[22] was administered. See Figure 3. His drawings were immature, equivalent to about age five. The organization of the drawings was poor, as was the fine motor control. On the Frostig Test for Figure Ground,[23] J.K. scored age four years, six months, while on the Frostig Test for Form Constancy,[23a] he scored age seven years. He could reassemble five of six forms on a divided form board in 150 seconds. We expect a first grade child to reassemble all six forms in 90 seconds. This indicates poor visual synthesis and poor spatial orientation.

J.K. could not respond simultaneously to the dual commands of the tactual angels test.[a] The Incomplete Man Test of the

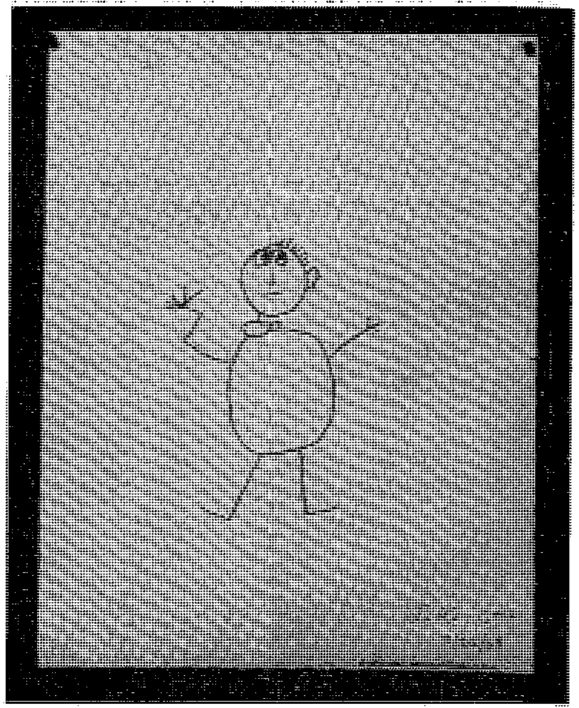


Fig. 4. Incomplete Man Test—J.K.

Gesell Institute test series was administered (see figure 4). His right-left discrimination was poor. He could not draw bilateral chalk circles either symmetrically or in a reciprocal yolked manner. J.K. could not walk a walking rail forward or backward, nor could he balance on a balance board. J.K. could not hop six times on one foot. He could not bounce a ball alternately, first with one hand and then the other. He could only jump three and a half inches high. All areas of motor control exhibited poor coordination.

Subject #2 is D.L., a male age five years, ten months, who was attending kindergarten. He was examined on March 14, 1969.

The prenatal and perinatal histories were normal. D.L. was born with a club foot which was operated on at age one and

[a]This test requires the subject to stand with his back to the examiner. The examiner touches one hand and one leg simultaneously. The subject must respond by raising the stimulated limbs simultaneously. The test is named after the childhood game angel-in-the-snow.

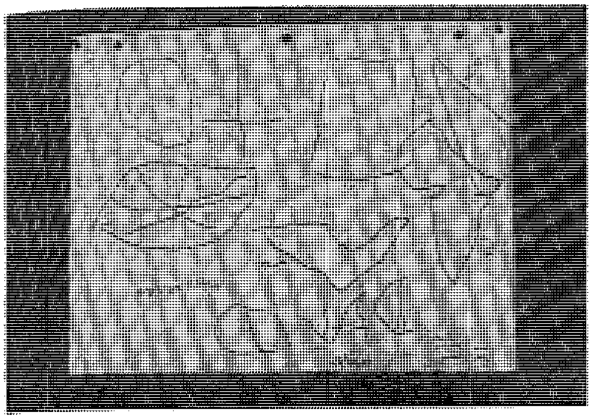


Fig. 5. Visual Copy Form Test—D.L.

a half. The motor milestones were unremarkable. He first talked at age 18 months, perhaps a little late. His articulation was slow in developing and is still poor. He cannot repeat such words as *animal* and *hospital* and has difficulty repeating the word *spaghetti* more than once. D.L. is right handed mostly and left eyed. His general motor development may be described as "clumsy." His fine motor development has apparently been delayed.

A visual analysis revealed no evidence of pathology. His visual acuity is 20/30 in each eye. A mild myopia is present but glasses have not been prescribed at this time. Tests to establish the level of binocular coordination indicated that D.L. has fusion and stereopsis.

A developmental and perceptual evaluation was performed and the following are some of the more significant findings. In the auditory area he was able to pass the Wepman Auditory Discrimination Test;[24] but could not blend any of the words on the Roswell-Chall Auditory Blending Test.[19a] He could not conceptualize the Birch Auditory—Visual Equivalence Test,[20a] using a code buzzer. On the Digit Span Test of the WISC,[17c] he scored age seven years, six months, and on the Block Design Test of the WISC,[17d] he scored 11 years, two months. On the Slosson Intelligence Test,[25] an individual verbal I.Q. test, D.L. scored 143.

His form perception is immature. The results of the Geometric Copy Form Test[22a] can be observed in figure five. Note that he writes his name backwards (mirror writing). He printed his name from right to left. Further note the difficulty incurred representing most of the forms. The performance represents about age four. For the results of the Incomplete Man Test of the Gessell Institute test series see figure 6. Note the name is printed correctly here. On the Frostig Test for Figure Ground,[23b] he scored age four years, nine months. In working, he switches back and fourth from left hand to right hand.

Most of D.L.'s performance in the perceptual motor areas was insufficient. He could not respond to dual commands in the tactual angels test, illustrating poor motor planning. He could not bounce a ball first with one hand and then the other; and his chalkboard circles were immature. Using a walking rail,[26] he could not walk the four inch side of the rail looking at a visual control. He could not hop six times on one foot.

Subject #3 is I.K., a female age six years, ten months, who was attending grade

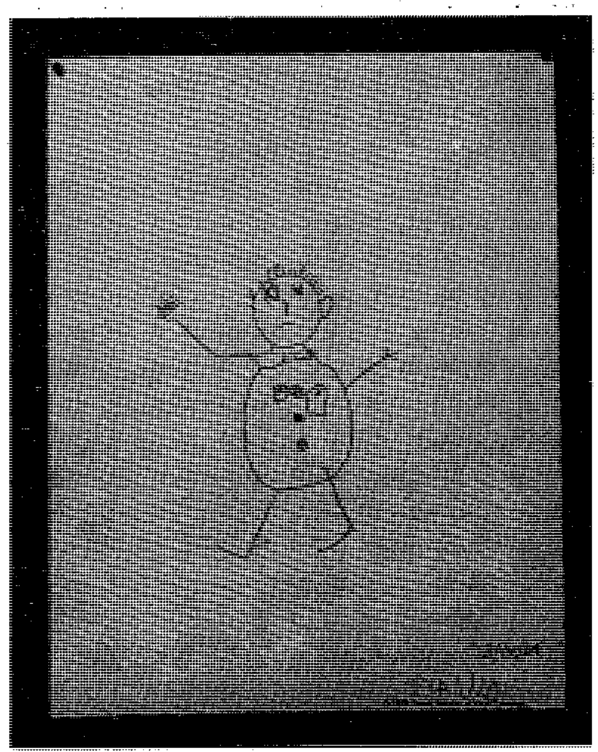


Fig. 6. Incomplete Man Test—D.L.

one. She was examined February 14, 1969.

The prenatal, perinatal and postnatal histories were unremarkable. She first talked at 15 months and her articulation was normal. Presently she is right handed and left eyed, indicating mixed dominance. Her gross motor development has been poor and her coordination is somewhat awkward. Right-left discrimination was normal. I.K. has a history of infantile rocking in the crib and head banging. She is a hyperactive and distractable child with a short attention span.

A visual analysis revealed no evidence of pathology in either eye. Her visual acuity was 20/25 in each eye. No significant refractive error is present, and glasses are not indicated at this time. Tests to establish the level of binocular coordination indicated no tendencies for the eye to deviate. Fusional reserves were within normal limits. In a stereoscope, she was able to demonstrate central fusion and stereopsis.

The Roswell-Chall Diagnostic Reading Test[16a] was administered, and from this we were able to ascertain that she was familiar with all the consonants and their sounds, albeit there is no discrimination problem. The only consonant blends she knew were *ch* and *sh*, but this is to be expected at the grade one level. While I.K. can recognize initial and final consonants, she cannot blend three letter words which are new to her. She does have some facility with the short a, but none with the other vowel sounds.

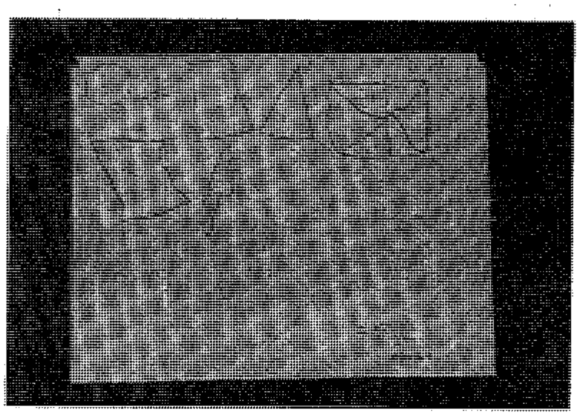


Fig. 7. Visual Copy Form Test—I.K.

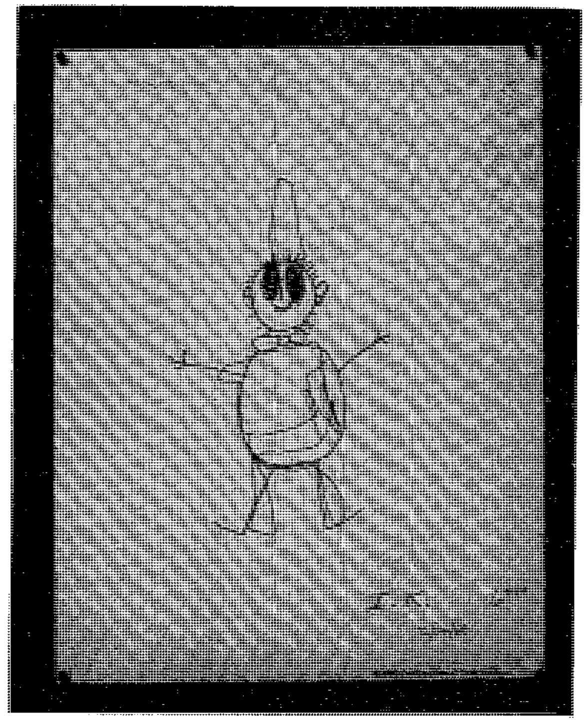


Fig. 8. Incomplete Man Test—I.K.

The Metroplitan Achievement Test, Primary I Battery,[15a] was administered to determine the extent of I.K's picture vocabulary and arithmetic concepts and skills. The word discrimination and reading tests were not administered. The results were.

	Grade Level
Word Knowledge	1.8
Arithmetic Concepts and Skills	2.1

I would summarize the reading test to indicate that I.K. is on the brink of learning to read.

A perceptual and developmental evaluation was administered and the following are some of the more significant findings. Using a tachistoscope she was able to recognize and record three digits at .1 seconds with an accuracy of about 50 per cent, placing her in the twentieth percentile of grade one.[18a] She did well on the Digit Span Test of the WISC.[17e] scoring age seven years, six months. She could repeat six numbers forward and only two backward. On the Birch Auditory-Visual Equivalence Test, [20b] she scored only five years, five months, indicating a lag in intersensory development in these areas. On the Block Design Test of the WISC,[17f] she scored age eight years, six months. She recognized linear conservation and reversibility on a Piaget Protocol, [21a] which is good.

The Geometric Copy Form Test[22b] was administered (see figure 7). The results are insignificant since they reveal a serious visual-motor and representational lag of about two years. This problem was further emphasized on the Incomplete Man Test of Gessell Institute (see figure 8).

Other examples of I.K.'s "scatter" in testing may be seen on the Frostig Test,[23c] e.g., she scored age five years, three months on the Figure Ground test, while scoring age nine years on the Form Constancy Test. She was able to re-assemble the divided form board[27] in 70 seconds indicating good visual synthesis and spatial orientation.

She had difficulty in responding to dual commands on the tactual angels test. Further evidence of her difficulty in reciprocal interweaving using both sides of the body, came in her inability to bounce a ball first with one hand and then with the other. She could not draw bilateral chalk circles either symmetrically or in a reciprocal yolked manner. She could not walk a walking rail forward or backward, nor could she balance on a balance board. She had difficulty alternately hopping twice on one foot and then twice on the other.

On the Slosson Intelligence Test,[25a] an individually administered and completely verbal I.Q. test, I.K. scored 119.

Summary

Table 1 shows a chart comparing the more significant findings in the three cases just cited. You will note that the symptoms and characteristics discussed earlier in this paper are clearly exhibited. Problems in the gross motor area were clearly evident in each case, e.g., hopping, jumping, ball bouncing and balance board were among the tasks which the subjects were unable to perform. Further, we can note that since the development of fine motor control, depends on the development of gross motor control, the latter being poor the former must of necessity be also poor. Visual motor representation showed a lag of approximately two years in each case. (See Visual Copy Form Test, figures 3, 5, 7) In the case of J.K. we see the presence of an exophoria at distance and near, which shows a lack of fine motor development. In the cases of J.K. and D.L. there were speech problems, related to a more generalized type of dyspraxia. All three cases showed deficiencies in the body schema areas involving gross motor, body planning, and spatial relations of the body. With impaired ability to interpret the spatial qualities of tactile stimuli, as in tactual angels, the body schema fails to mature and consequently motor planning is difficult. As motor planning improves and hence the individual is able to accomplish skilled acts of perception of the spatial and temporal elements of tactile and kinesthetic stimuli, the body schema develops. This integrative mechanism is receipt to other perceptual processes and other cognitive functions such as academic learning.

In each of the three cases, the verbal I.Q. (scores of 149, 143, 119) were above average. In other tests of conceptualization these children also performed well, e.g., on the Block Design Test of the WISC,[17g] each child scored above age level. On a Piaget Protocal [21b] the two youngsters tested exhibited linear conservation and reversibility. Yet all of these children are functioning far below average in their academic spheres. I suggest that the breakdown is not occurring at the higher levels of conceptualization, rather in the very fundamental and basic areas as outlined earlier. Motor planning and the necessary processing of information are lacking in these youngsters. **AOA**

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811 Grange Road
Teaneck, New Jersey 07666

TABLE 1

A Summary of Case Histories and Clinical Findings of Three Cases Cited

Clinical Test	Case #1: J.K.	Case #2: D.L.	Case #3: I.K.
Age	6+10	5+10	6+10
Date of Evaluation	March 22, 1969	March 14, 1969	February 13, 1969
Grade	Class for Neurologically impaired	Kindergarten	1st Grade
I.Q.	W.I.S.C. Verbal 149 Performance 86 Full Scale 121 Slosson (verbal) 150	Slosson (verbal) 143	Slosson (verbal) 119
Parents description of Gross Motor Abilities	Poor	Clumsy	Awkward
Hyperactive?	Not overly; increases in situations of stress	Extremely	Yes
Distractible?	—	Yes	Yes
Attention Span?	Normal	Average	Short
Language development —first word	20 months	18 months	15 months
Present articulation	Lisp	Poor	Normal
Hopping—6 times on one foot	No	No	No
Balance Board	No	No	No
Walking Rail—forward and backward	No	No	Borderline
Vertical Jump (6″)	No	No	No
Single Chalk Circle	Right hand counter clockwise	Right hand clockwise	Right hand clockwise
Bilateral Chalk Circles—			
Symmetrical	Unrelated	Cannot sustain	Cannot sustain
Reciprocal	Cannot sustain	Cannot sustain	Cannot sustain
Tactual Angels	Poor	Poor	Poor
Right-Left Discrimination	Poor	Poor	Good
Geometric Copy Forms	Approx. age 5	Approx. age 4	Approx. age 5
Frostig—Figure Ground	4+6	4+9	5+3
Frostig—Form Constancy	7+0	8+3	9+0
Auditory-Visual Equivalence Test (Birch)	Does not conceptualize the spacing of dots	Does not conceptualize the spacing of dots	5+5
Digit Span (W.I.S.C.)	7+6 6 digits forward 2 backward	7+6 5 digits forward 3 backward	7+6 6 digits forward 2 backward
Block Design (W.I.S.C.)	7+4	11+2	8+6
Piaget Protocol			
Linear Conservation	Yes	Not tested	Yes
Area Conservation	No	Not tested	No
Reversibility	Yes	Not tested	Yes
Key Form Board	68 seconds Tactile-Visual++ Picks up pegs with right and left hands Inserts pegs with right and left hands—shows mostly right to left transfer	57 seconds Visual-Tactile Picks up pegs with right and left hands simultaneously Inserts pegs with right and left hands simultaneously	50 seconds Tactile-Visual Picks up pegs with right hand Inserts pegs with right hand

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