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Man's phylogenetic development has resulted in a potential for environmental interaction in a symbolic and conceptual manner. There are ontogenetic requirements to develop such potential. The process by which man learns is sequential and involves perceptual-motor-cognitive abilities. There is an optimum respectivity period at each developmental level; and if this period is passed without learning taking place, guidance should be provided to avoid performance difficulties. Physical movement is the basis for perception. A goal of developmental efficiency is the reduction of movement through symbolic manipulation and visualization. Developmental guidance must recapituate ontogeny. The implications of developmental inadequacies in perceptual motor skills in adults, emotionally disturbed, and mentally handicapped children are discussed, and many citations are included in this master's thesis. (MS)

A RATIONALE FOR DEVELOPMENTAL TESTING AND TRAINING*

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A RATIONALE FOR DEVELOPMENTAL TESTING AND TRAINING *

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"The advancing forefront of human knowledge and conceptual ability means that each succeeding generation must cover more ground in order to be educated. Secondary school pupils today handle concepts and symbol systems that top scientists a few generations ago had not even dreamed of. To do its job effectively, our educational system needs more than teachers and books. It needs all the technological and symbolic machinery that mediates the new knowledge. It needs all the avenues of verbal and non-verbal communication that has been developed. For the machines and techniques of society are more than the fruits of man's knowledge; they are the means of communicating specialized knowledge and skills and the tools for generating new knowledge, skills, techniques and machines." (1)

Barsch (2) states that at least thirty percent of the pupils enrolled in school today will become academic casualties, in that they will be unable to keep up with the requirements of their curricula. He suggests that one of the reasons for this high casualty rate is the fact that our educational curricula are predetermined before the child is born; we assume that all children of a given chronological age came to school with the same ability to learn.

For many years, educators have been discussing the existence of some vaguely defined attributes under the heading of "academic readiness". They list auditory readiness, visual readiness, emotional readiness, experiental readiness and a host of similar readinesses. There are few, if any specific indices of readiness, and those that are listed show little or no predictive value concerning the child's future work in school.

The elementary schools have a plethora of material purporting to develop readiness, but most of them require such fine visual and eye-hand coordination, that Harris (3) was prompted to state, "...using published readiness material is of questionable value because many children are well advanced in this skill and don't need it, and for others, it is too difficult."

A major portion of academic difficulty has naturally centered around reading disability. Reading not only represents one of the highest order levels of symbolic and conceptual manipulation, but it is the very cornerstone of other learning activities. Eustis (4) generalizes the reading problem under the term, "specific language disability" or dyslexia and defines it as:

"...the ability in an otherwise normal, healthy and intelligent child, to master reading, writing and spelling as quickly and easily as he masters other subjects. He usually understands (sic) arithmetic well, although he is more likely than others to produce a wrong answer on paper by reversing the order of the digits."

Stuart (5), Eustis (4), Hulbert (6) and Delacato(7), list some of the common characteristics of specific language disability:

1. Poor visual perception and memory for words.
2. Poor auditory memory for individual sounds in words.
3. Reversals and confusion in direction.
4. Poor recall for production of simple figures.
5. Ambidexterity.
6. Clumsiness, poor coordination.
7. Poor ability to reproduce rhythm sequences.
8. Speech disorders.
9. Hyperactivity.
10. Perceptual confusions regarding figure ground relationships.
11. Sex associated condition, i.e. 70% to 80% male.
12. Familial predisposition.
13. Binocular instabilities.
14. Inability to verbalize right and left.
15. Speech delay, i.e., "did not hear sounds well".
16. Stuttering.
17. Difficulty with small or simple words.
18. Agraphia or dysorthographia, i.e., poor handwriting.
19. Spelling problems.

Attempts to uncover a general rationale to relate all these apparently disconnected symptoms have largely been unsuccessful. Theories range from the emotional-motivational (8) school of thought, through Robinson's (9) innocuous multiple causation concept, to the strictly neurological approach. (10) (11) (7)

THE ROLE OF VISUAL ANOMALIES IN READING DISABILITY

The only consistent correlation with reading disability from an optometric viewpoint has been binocular instability. (12) (13) (9) (14) (15) (16) (17) (18) (19) (20) (21) (22) (23) (24) (25) Robinson and Heulsman state, "... the only visual scores which consistently differentiate high and low achievers... involved binocular visual performance." (27**)

On the other hand, many studies (28) (29) (30) (31) (32) (33) come to the conclusion that visual anomalies have little or no bearing on reading performance except in extreme visual impairments. Heulsman (34) summarizes the dilemna by stating, "...outline form perception skill <u>is and is not</u> related to learning how to read, tachistiscopic training <u>does and does not</u> contribute to attaining a more rapid reading rate and visual skills <u>are and are not</u> related to learning how to read."

Edson (35) concludes, "In the absence of a significant degree of correspondence between the outcomes of the vision tests and reading test scores, the findings of the study to not support the opinion that achievement in reading is limited by visual skills". He notes that if visual anomalies of any level are related to achievement in reading, the level that is educationally important is not that which is usually employed as the referral point for ocular examination. It would appear that we are measuring the wrong things in the classical visual analysis or screening.

Several workers have found that a more holistic evaluation of the child's performance has been more fruitful in predicting and explaining reading and general academic difficulties. (36) (37) (38) (39) (40) (41) These studies have evaluated the perceptual-motor organization level of the child on a performance level. Others (42) (43) (44) (45) (46) (47) (48) have reported that visual or perceptual-motor training has resulted in an improvement of academic performance.

** The fact that most diligent researchers mention aniseikonia as an etiological factor in reading disability (26) is most unusual when we realize that there are probably fewer than 100 eikonometers in the country.

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We shall attempt to describe the development of academic readiness; the learning how to learn. Getman (49) states, "Parents must realize that a child learns all he knows. Very little comes with him at birth except the basic machinery for learning, and the children must even learn how to learn. Infants do not arrive knowing how! The fact that an infant must learn how to walk and talk is fully accepted by everyone. It is most important to know that the infant must also learn how to see, feel, smell and taste. The machinery for each is present, but he must learn how to use it."

WHY AND HOW THE BASIC MACHINERY WAS DESIGNED

"Man has both an ontogenetic and a phylogenetic history. He has evolved from the most primitive forms of life and he carries with him the evidences of this development. To understand his function we must consider where he came from, how far along he is, and where he is going." (50)

Gesell (51) in his vivid prose, points out, ". . . culture is accumulated; it does not grow. The glove goes on the hand; the hand determines the glove. And the hand, by the way, is a primitive survival, shockingly similar to the hand of the ancient tortoise who swam the sea and walked the earth millions of years before the advent of man."

If we examine the phylogenetic history of man, several striking adaptations will be noted during the period of transition from an arboreal or tree dwelling hominoid to a terrestrial or ground dwelling man. Obviously, the major change was in the adaptation of an erect posture and locomotion over land rather than through the trees. Ardrey (52) suggests that this was a predatory necessity, accompanied by the use of weapons which multiplied the demands on the nervous system for the co-ordination of muscle, touch and sight. "Far from the truth lay the antique assumption that man had fathered the weapon. The weapon, instead, had fathered man."

He continues (52a), "...the specialized human foot makes possible a balanced, erect posture and rapid movement without recourse to an all-fours position. No ape or monkey has this capacity...his hands are never freed permanently for chores other than locomotion. Similarly, the special development of that mass of muscle centered in the human buttocks makes possible agility and all the turning and twisting and throwing and balance of the human body in the erect position. As the brain co-ordinates our nervous activity, so the buttocks coordinate our muscular activity. No ape boasts such a muscular monument to compare with ours; and it is a failure more fundamental than his lack of an enlarged brain."

Hulse (53) states: "Anthropoids are characterized by the possession of nails rather than claws on all digits, by by stereoscopic vision and the ability to distinguish colors, by well developed manipulative ability, by cerebral expansion to the rear which covers the cerebellum completely, by increased convolution of the cerebral cortex or neopallium, by facial muscles which permit a variety of expressions, by tongues unsuitable for lapping and by a high degree of dependence on social learning for a substitute for inate reflexes."

Ardrey (52b) and Hulse (53a) stress the sensitive finger pads without claws. Hulse goes on to postulate, "Primates are so constructed that they can learn more about their surroundings by combined use of the hand and eyes than by any other means...This standard primate technique of investigation is primarily responsible for the eventual development of human mentality."

We may summarize the unique attributes of man as: (54) (55) (56)

1. Erect posture.
2. The forelimbs were freed from locomotor tasks and became available for manipulation -
   (a) The opposable thumb and supportive and manipulative hands.
   (b) Eye-hand co-ordination was sharpened and developed.
3. Facial changes -
   (a) Anterior placement of the orbits permitting overlapping stereoscopic fields.
   (b) Facial expressiveness and changes in the labia and vocal structures permitting refined communication patterns.
4. The evolution of vision as a distance receptor.
5. The development and maturation of the antigravity reflexes and the connections between the ocular, vestibular, proprioceptive, kinesthetic and speech-auditory complex were developed more fully. The medial longitudinal fasciculi still exists today as an interconnection between the various action systems.
6. There were concurrent sociological changes requiring communications between larger and more complex cultural units.
7. The evolution of symbolic language and writing and the appreciation of history and causal factors in the environment. (1) (57)

HOW THE BASIC MACHINERY IS BROKEN IN

There is a dictum in biological sciences, "Ontogeny recapitulates Phylogeny". Phrased less succintly, the maturation and development of any individual member of the species may duplicate the maturation or development of the entire species from its antecedent life forms, over the ages. Gesell (51a) states, "Infancy is the period in which the individual realizes his racial inheritance. The inheritance is the end product of evolutionary processes which trace back to an extremely remote antiquity."

THE ROLE OF MOVEMENT IN CHILD DEVELOPMENT

Coghill (58) and Gesell (56) point out that the first behavior to develop is not a response to sensory stimulation, but results from the direct action of the motor systems.

Embryologically, the first neurological system to develop is the motor system. The motor system is laid down and becomes functional before the perceptual system is ready. The association system is the last to develop and is built upon the two previous systems which are already operating...The first learnings of the human organism are motor learnings. In early childhood... motor activities play a major role in intellectual development.(59)

Some seventy years ago, Maria Montessori (60) stated, "Movement is therefore the essential of life...for it is precisely the characteristic which distinguishes not only man, but all the animal kingdom from the vegetable world."

Hendrickson (61) postulates, "The human system is arranged for the purpose of movement and the detection of movement. Movement is the key to growth and development; to sensory inputs and motor outputs; to sensing, knowing and learning."

Fitzgerald (62) states that perception begins with gross motor co-ordination, and Weinstein (63) quotes Herrick and Sherington as describing movement as "the seedbed of mentation" and the "cradle of the mind".

A. The development of the body schema or body image.

The movement patterns of the infant are generalized, undifferentiated action patterns of the limbs, head and neck. They do not at first lead to locomotion, but have as their result a development of the infant's awareness of his own body: (64)

1. Afferent feedback arc from efferent neurons of the

pyramidal tract.

2. Kinesthetic and proprioceptive afferents from the muscle spindles, tendon organs and those of the joints.
3. Postural afferents from Nerve III. These signal three types of data:
   (a) the position of the head with regard to the gravitational axis,
   (b) acceleration of the head in space, i.e., movement of the head from one place to another,
   (c) Rotation of the head around any axis.
4. Visual inputs from the retina and the extra-ocular muscles.
5. Other sense inputs such as hearing and tactualization.

With continual experience, these sense inputs based upon movement will be matched; first two, then three, then ultimately all the input modalities will be matched and found congruent. The infant can check one identification against the other; he can begin to integrate the various sense fields. (50a) The senses were meant to function in synesthesia; two or more modalities blending. (65)

Again, Maria Montessori stated, "It is possible for us to move without touching anything... but when we touch something as we move, two sensations are mixed up together-tactile and muscular...this knowledge may be integrated with that gained through vision, thus giving a more exact concreteness to the perception of any object." (60a)

Kephart (66) summarizes by stating, "When we touch a part of the body, we see the act, but simultaneously, we also feel it. Intersensory stimulations are more closely bound together here than elsewhere. Motor responses are likewise more closely bound together and more closely related to sensory impressions. Thus the body schema becomes more than a simple perception, it becomes a very different type of whole which has certain very unique properties. It is this which becomes the point of origin for all the spatial relationships for objects outside our body." (66a)

Bender (67), Bender and Silver (68), Strauss and Kephart (66a), Belmont and Birch (69), Kittamura (70), Gellert (71), Gellert and Stern (72), and Frostig (73) all place great stress on the awareness of self as expressed in the body image and indicate the importance of this awareness on visual perceptions and spatial orientation.

B. The role of movement in the awareness of space.

"The child can come to an appreciation of distance and intervening space only by translating his body from one place to another. He begins to acquire a dim sense of remote objectives and distance covered if he is permitted to creep and walk... If as so often happens, even his locomotion is restricted or denied, his spatial orientation remains beknighted...Form is dependent upon ample exploration through active touch. His finger tips must make journeys to explore outlines and confirmations. (65a)"

Gesell (51b) in 1928 distinguished at least twenty-three stages in the patterning of prone behavior which eventuates in standing and walking. More recently, Delacato (7) lists some thirteen patterns of locomotion but it is important to realize that locomotion serves one purpose and one purpose only; to bring about a change in location. A plant, (c.f. Montessori's differentiation between animal and vegetable) would have no need of the spatial sense of location without the possibility of locomotion.

Kephart (66b) states, "We have no direct information concerning spatial relationships in our environment. Through kinesthesia, or muscle sense we can estimate the amount of muscular movement required to make contact with an object... Only through the translation of movement into space do we obtain knowledge of the distance to an object...Space is therefore a concept developed in the brain; it is always a secondary sensory datum."

In the normal child, the movements through space are monitored and guided by vision. Gesell (65b) states, "An infant does not really wake up until he begins to look; and when he ceases to look, he goes to sleep... In the early months, looking is half of living." Strauss and Kephart (50b) continue, "Vision is unique in that it is the only organ which gives us simultaneous information concerning space in any detail. Other sensory modes, adequate at one time to the restricted environment of the organism have become subservient to vision as the environment has widened." (50c) He suggests that the amount of convoltion or folding of the visual cortex is the highest in the brain, reflecting the fact that the fibers are the most basic and representative group used in our activities. (50d)

Smith (74) (75) (1) postulates a neurogeometric theory, which states that the organization of visual behavior and perception is determined by the relative geometric displacement of motion patterns and the visual feedback of particular postural, transport and manipulative movements. Spooner (76), Prince (77), and Walls (78) suggest that the role of the eyes in maintaining body posture is critical. Walls (78) goes so far as to suggest the visual orientation is the standard and that there will be disorientation in the total perceptual space if non-visual orientation does not agree with visual. He suggests that Stratton's famous inversion experiment before the turn of the century actually involved a retraining of the tactual and kinesthetic space references and body image cues to conform to the inverted visual image supplied by the prism.

This point is open to question; most researchers stress the fact that the motor came first, and the infant; "... then experiments with the movements of his eyes until it gives him information which matches his motor information. Since the body of motor information is reasonably stable, he stabilizes the visual information when a match occurs-he has established a perceptual-motor match. When this match is adequate, he can drop out the intervening motor manipulation and use his now stable visual information to control the eyes and thus control new visual input." (79)

Held (80) suggests three processes: (a) the development of normal sensory motor control in the young, (b) the maintenance of that control once it has been developed and (c) the adaptation of changes or apparent changes reported by the senses of sight and hearing. He points out that the adaptation is necessary on the sensory side due to the fact that the afferent or input signals must change with increasing separation between the eyes and ears and on the motor side to the fact that the growth of bone and muscle must call for a gradual modification of the efferent or output signals.

Held further shows in a series of experiments, that active movement, initiated by the subject, as opposed to passive movement or patterning was more effective in producing adaptations to artificially distorted visual inputs. He concludes, "The importance of self-produced movement derived from the fact that only an organism that can take account of output signals to its own musculature is in a position to detect and factor out the decorrelating effects of moving objects and externally imposed body movement."

Weinstein (63) suggests that evaluation and training of body posture and co-ordination might be more fundamental than immediate or postponed visual training. He goes on to imply that early recognition and management of pre-squint symptoms might altogether prevent the emergence of strabismus. Flax (81) suggests that some binocular deviations manifesting themselves as frank strabismus might be related to lack of general control in integration of the gross motor system. He notes that "...a significant portion of the optic nerve fibers do not seem to enter the seeing portion of vision at all, but are intimately involved with the vestibular and postural mechanisms of the body."

Frostig (73a) and Ayres (82) indicate that whenever a sighted person reaches, runs, jumps, kicks or steps over an obstacle, the smooth accomplishment of every action required adequate eye-motor co-ordination. Space perception and planned motor sequences are involved, but such tasks are very difficult without visual-motor co-ordination.

It is difficult, therefore, to conclude unequivocally whether vision or the tactual-kinesthetic inputs are the invariant standard in the mature, sighted person. It is probably nearer to the point to realize that both input systems must match and that mismatching will result in distress in spatial orientation and higher perceptual-cognitive abilities. Kephart (66c) and Barsch (2) point out that a child who has difficulties with space is likely to have similar difficulties in thinking. Frostig (73b) states, "A child with disabilities in his perception of space is handicapped in many ways. His visual world is distorted, he is clumsy and hesitant in his movements and has difficulty in understanding what is meant by the words denoting spatial position, such as 'in', 'out', 'down', 'before', 'behind', 'left', and 'right'. His difficulties become more apparent when he is faced with his first academic tasks, because letters, words, phrases, numbers and pictures appear to him distorted and confusing. To give the simplest and most frequently encountered examples, a child with difficulties in perceiving the proper position of an object in relation to his own body is likely to perceive 'b' and 'd', 'p' and 'q', 'on' and 'no', 'saw' as 'was', '24' for '42' and so on. This, of course, makes it difficult if not impossible for the child to learn to read, write, spell and do arithmetic".

It is important to distinguish between arithmetic and mathematics. Arithmetic, in its earliest form, is primarily a spatial task and may best be learned by gross movements and translations through space. Later, number sense and the basic arithmetical operations may best be appreciated through manipulation of objects of varying size, as suggested by Montessori. Still later in the development of the child, numbers may be appreciated by enumeration or counting and then at last, on a purely symbolic level. Mathematics suggest symbolic visual and conceptual manipulations rather far removed from the early spatial and tactual-kinesthetic experiences of the child and will also involve reading comprehension skills of his development, do quite well in arithmetic but fare poorly in mathematics. Inversely, a child with good symbolic and conceptual ability might do well in abstract mathematics, but be poor in basic arithmetic. The latter child is not likely to be truly adept, since the implication of poor spatial awareness is not compatible with a stable conceptual ability.

C. The special motor activities and the development of eye-hand relationships.

"The earliest movements of neurogenic origin...are those that start with the head and trunk and which apparently involved the grosser musculature. This is followed by a differentiation so that movement of small segments such as the extremities, occur within the larger total pattern. When individuation is complete, specific responses may appear in relative localization when the total pattern is inhibited." (83)

Conel has also found sequential priorities in growth even within particular areas of the cortex. For example, the motor cells that control the muscles of the upper arms develop interconnections before those that control the hands. (Parents know that a baby can flail its arms about long before it can control its fingers sufficiently to pick something up.) As the parts of the cortex continue to mature, all of the body's responses to stimuli and all of his movements become more precise. (84) (75)

Gesell (51b) has classified these developmental trends under the general principle of (a) cephalo-caudad and (b) proximal-distal growth and maturation. Cohen (85) has stressed the need for full sequential development of gross to fine movement before cultural stress is placed on early fine or special motor control. He suggests that early overemphasis of fine motor control may lead to stresses and instabilities which may manifest themselves as postural deficiencies, poor body co-ordination, poor reading and writing, negative self-concepts and the host of psychological problems that accompany such self concepts.

Gesell (65c) (56a) has stated, "The baby can reach with his eyes before he can reach with his hand, which is in accord with the cephalo-caudad trend of neuromotor development." He states elsewhere, however, "...Vision does not function in isolation: (Ital. RSA) developmentally and physiologically it is closely correlated with other sensory activities, particularly touch and kinesthesis. Tactual perceptions are visual-tactual perceptions for the normal mind." (65b)

Kephart stresses the need for matching or synesthesia by stating, "The child must learn to explore with his eye the same way he previously explored it with his hand. It is important, however, that the exploration with his eyes duplicate the exploration with the hand, and that the resulting information match the earlier information." (79a) "Children in their early years touch everything they see, obtaining a double image, visual and muscular." (60a)

The tonic neck reflex described by Gesell is the beginning of eye-hand relationship, since this is the first opportunity for the infant to regard his own hand and its movements. Haines has shown that the accommodative level of the infant is at the distance of his hand, lending support to this hypothesis.

Therefore, while it may be true that the infant can reach with his eyes before his hands as stated by Gesell, it is doubtful that such early scanning of his environment leads to meaning and understanding without the intervening stage of tactual and motor exploration and the matching of the two sense inputs. The early fixations of the infant may be called sight, but they are not to be considered as vision, or a meaningful exploration of the environment. (86)

Hebb (87) states, "The first learning involving manipulation in the normal primate, would be accompanied by eye movement; but later, in man at least, there is the capacity to move the hand to the point one only thinks of looking at. In this case...the motor process is subliminal for eye movement, but still with an integrating function for other cortical processes. This makes adult learning primarily perceptual...but it still leaves a great emphasis on the motor learning of infancy."

Morgan (88) points out that the pleoptic techniques for the treatment of strabismus and amblyopia stress matching of ocular direction with hand, arm and auditory activities. Weiner (89) found that tactual perception acts in the development of braille reading skills in a manner similar to visual perception and imagery in sighted children.

As we develop the ability to explore our environment visually, we tend to drop out the intervening motor inspection and progress along the classical heirarchy:

1. Tactual.
2. Tactual-visual.
3. Visual-tactual.
4. Visual.

D. The eye movement patterns.

"Vision is unique in that it permits us to inspect our environment both simultaneously and serially. This possibility of a change in the nature of the presentation is another reason why vision is so important among the senses and why we use it so exclusively in constructing our space world". (50b)

If the transition from tactual and manipulative spatial exploration to the visual is to be made efficiently, the eyes must provide the same input time after time. Fine epicritic visual explotation necessitates macular vision; the narrow span of the macular area necessitates rapid successive or serial fixations as noted by Kephart. It will serve the child to no avail if he attempts to practice the successive ocular fixations required to visually inspect a rectangle if his eyes do not move the same way twice.

Instability of input is not compatable with learning the perceptual-motor matches required for efficient learning. Kephart states, "Clinicians have so frequently noted that minor defects of the input apparatus give the individual more trouble than a much more major defect appears to cause. The interference caused by the minor defect is transient and interferes with the consistency of the information. The interference from the major defect is always present and can be compensated." (66)

The interferences and disturbances in comfort and efficiency caused by binocular instabilities is well known to clinicians. Suppressions, postural deviations in a search for monocularity, avoidance of the visual task, asthenopia and loss of meaning from the near point tasks are but a few of the common clinical signs of this problem.

The research reported thus far has stressed the ascendancy of vision as the primary input system for the exploration of space. If instabilities of the oculo-motor system make such visual information processing inefficient or uncomfortable, the individual must revert to other systems, regressing to the tactual, or jumping ahead to an unstable speech-auditory system, with an attendant loss in efficiency or flexibility. His environmental interactions and interpersonal communications, must be affected by his lack of visual processing. In normal conversation, we learn as much, if not more, by watching the facial expressions and postural sets of our companions that we do by hearing their words.

The control of the oculo-motor system is dependent upon the facility of the special motor system and in turn, on the efficiency of the gross or general motor system. While there are different loci for the different movement systems, it is still the same brain that controls the legs, arms, hands and eyes. Disorganization in one motor mode is likely to be reflected into other modes. The oculo-motor system is likely to be a reflection of poor co-ordination in prior ontogenetic development, and is also likely to be a harbinger of poor perceptual ability regarding visual judgments of size, shape, form and distance.

Getman (49a) states, "There is increasing evidence that eye movement abilities can act as a restriction upon language development. Children are frequently seen who have not acquired a vocabulary that indicates a concept of direction of movement... it is interesting to note that many clinicians... are reporting an acceleration of language development during and after training of eye movements."

It will be remembered that the review of the literature concerning visual factors in reading performance singled out binocular instabilities as the only visual correlate. These considerations have led Getman (90) and many other clinicians to state that granted one single observation of the non-achieving child, it would be an evaluation of the quality of the oculo-motor systems.

THE ROLE OF DOMINANCE

Gesell (56b) articulates the Principle of Reciprocal Interweaving as: "The organization of reciprocal relationships between two sets of counteracting functions or motor systems is ontogenetically manifested by more or less periodic shifting ascendancies of the component functions or systems with progressive integration and modulations of the resultant behavior patterns." As a special inflection of the Principle of Reciprocal Interweaving, he further postulates the Principle of Functional Asymmetry, in which bilateral and ipsilateral members must be brought into homolateral and contralateral co-ordination." (51c)

"Throughout early human development there is an almost periodic interweaving maturation, now of symmetrical and then of asymmetric behavior forms, with corresponding shifts in postural manifestations" (51d)... "Man, in spite of his bilateral construction, does not face the world on a frontal plane of symmetry. He confronts it at an angle and he makes his escapes, also obliquely.

"He develops monolateral aptitudes and preferences in handedness, eyedness and other forms of unilaterality... Perfect ambidexterity, if it exists, would seem to be almost an abnormality, because effective attention adjustments require an asymmetric focalization of motor set. The behavioral center of gravity always tends to shift to an accentric position... Reciprocal interweaving operates to preserve harmony and balance; but in actuality, there is a superadded ontogenetic deflection to insure the greater efficiency of functional asymmetry." (51c)

He gives examples (65d) in describing the sixteen week infant who is now transcending the asymmetry of the tonic neck reflex which threatened to make him one-sided. He is bidextrous, and tends to move his arms in unison. However, by the age of twenty eight weeks, he is transcending this phase of symmetry, and makes a one-handed approach. Throughout life, in all systems, right and left, upper and lower, tactual and visual, verbalization and visualization, the principle of reciprocal and interweaving describes and explains the ebb and flow of behavior.

Once again, Montessori (60b) anticipates it all when she states, "The child possesses a functional ambidexterity, which is very common among children who are three or four years old, but which disappears later."

A. Phylogenetic and ontogenetic considerations of dominance.

Ardrey (52b), Delacato (7a), and de C. Downer (91) point out that infra-human animals, including the ape in a state of nature, are ambidextrous and there is an apparent absence of cerebral dominance. Ardrey suggests, "Only the specialized capacity for manual dexterity demanded by the continual use of weapons and tools can seem to account for the development of that singular human attribute, the dominance of one hand over the other... Speech, as well as right handedness are probably developed from the necessities of the specialized manual way."

Scheibel and Scheibel (91a) postulate, "An animal whose brain is bilaterally symmetrical cannot differentiate between stimulii arriving at homogeneous points, being limited to mirror image responses upon homologous right and left stimulation. Awareness of spatial position is therefore dependent upon asymmetry of the receiving system, and evolution consists of increasing that asymmetry... With each increase in asymmetry, more can be known about the surface of the body and its environment. Man is presumed to be approaching that final category of asymmetry because he can distinguish right from left, but he frequently makes mistakes."

"Since awareness of spatial position may well depend on asymmetry of the receiving system, our paired brain becomes rather than a holdover from an isomorphic past, and increasingly useful mechanism for appreciation of the environment along a new axis of orientation."

Jung (91b) recalls Coghill's view on the origin of central decussations; they may be needed to facilitate response to sensory stimuli (impinging on one side of a bilaterally symmetrical body) by means of muscular activity which is concentrated on the opposite side. He also stresses that we cannot call one hemisphere dominant as such. Dominance manifests itself only for special functions. In the left hemisphere dominance exists only for language, (sometimes for left handers too), including reading and calculation. In the right hemisphere, dominance seems to exist for certain spatial and practice functions and some special gnostic performances.

Hecaen (91c) suggests, "The role of the left hemisphere is to construct new functional schemas in relation to superior activities and the highest human performances, while the task of the minor hemisphere consists in the preparation of foundations... More briefly, one could say that the dominant hemisphere must create the necessary conditions for the realization of these activities."

The entire question of cerebral dominance is beclouded by the fact that men like Sperry (91d), de C. Downer (91e), and Mishkin (91f) have shown that the corpus calloseum and other interhemispheric connections of the brain are only dimly understood; there is considerable transfer between the two hemispheres under normal conditions.

Schrock (92), Hebb (87), and Mishkin (91f) have shown that tachistoscopic recognition of words and letters in the right visual hemifield is two to three times better than recognition in the left visual hemifield. On the other hand, readers of Jewish as the mother tongue, recognize more words to the left of the fixations point; Jewish is read from right to left. Schrock quotes Melvin Dunn, and suggests that these findings may indicate that the cerebral hemisphere mediating language function in any individual may be dictated by the structure of the mother tongue. Since English requires form recognition in the right hemifield while reading and its grammatical structure, the left hemisphere may be favored irrespective of the sidedness of the individual. Spache (24) also reports that ninety-four percent of the people have the language center on the left side of the brain despite laterality preferences throughout the body.

Benton (91g) suggests that a great deal of the difficulty and confusion regarding dominance and cross dominance may occur, "...because our present methods of categorizing individuals with respect to handedness are much too imprecise and simply do not do justice to the facts. They possibly constitute a significant source of error in our determination of the relationship between handedness and dominance... The least controversial fact in this area is that the left hemisphere is dominant for language in the very great majority of right-handed persons. On the other hand, we know that the second part of the classic formula (i.e., that the right hemisphere is dominant in sinistrals) does not hold. The dominant hemisphere for language in sinistrals is essentially unpredictable."

Similar confusions may exist in the tabulation of the preferred foot. If a child kicks a ball with his right foot, which foot is dominant, the right foot which does the kicking, or the left foot which serves to maintain the equilibrium of the body?

B. The role of the midline in laterality.

The infant, through his synesthesia of visual, proprioceptive and kinesthetic inputs becomes aware of the existence of a right side of his body and of a left side of his body. It is interesting to note that in the first three or four months of life, an infant will grasp the hands of his parent if they are presented on either side of the body. He will not retain this grasp if the two hands are brought together on the midline of his body. He will even grasp his own hand to one side or the other, but will release the grasp if the hands are brought onto the midline.

After the fourth month of life, he will grasp his own hands in what Gesell calls the "prayerful attitude", and will grip the hand of the parent on the midline. The ability to oppose the hands at midline is the beginning to purposeful perhension and marks the beginning of the left-right stage of integration of the two body halves at the midline.

With increasing development and perceptual-motor sophistication, he is able to bring his left hand over to the right side of the body and vice versa. This is yet another example of the reciprocal interweaving of Gesell.

It must be realized that the midline is a perceptual-motor discontinuity without parallel in our world. The paired brain switches control at the midline of the body and our visual space. The early movements of the infant's arms and legs are from the inside out, or outside in, terminating at the midline. In crossing the midline, a hand must first be moved outside in, and then without hesitation, inside out on the opposite side of the body.

If the movement is of the right hand, starting from the right side of the body, the efferent control of movement is in the left hemisphere, and the afferent visual input is received from the right hemifield of vision in the left visual cortex. When the midline is crossed, the efferent motor control is still in the left hemisphere, but the afferent visual impression now emanated from the left hemifield of vision and is received in the right visual cortex. This smooth shift and countershift of the controlling hemisphere is a learned skill and indeed, the absence of this skill frequently is noted in children with perceptual motor problems.

"In extreme cases of midline difficulty the child will be observed to split his performance, performing that part lying to the left of the midline with his left hand and that part lying to the right with his right hand. In less severe cases, he will, by distorting the position of his body or the position of the drawing with relation to his body, throw all of the activity to one side of the midline and thus avoid the problem of crossing." (66d)

As an example of the sequential interdependence of motor learning, children who have difficulty in combining their body halves when walking on a line or criss-crossing over a line will in turn show difficulties in ocular pursuits across the midline and will show difficulties in drawings and form perception with the task involved crossing the midline.

"It is through experience with the movement of the two halves of the body, observing the differences between these movements, comparing these differences in sensory impressions and so forth, that we sort out the right side from the left and ascribe certain differentiating qualities to each. The primary pattern out of which this differentiation develops is that of balance. When experimenting with the balancing problem, the child must learn right from left." (66e)

Kephart (66f) further describes two means that a child may utilize to avoid having to make decisions concerning laterality:

1. He may be completely bilaterally symmetrical. In such a child, we will see both sides of the body brought into play when only one is necessary. The other arm or hand is tensed or is making small movements that are mirror images.
2. The opposite problem is one in which the child becomes almost completely one sided. In every activity, he performs with one side and merely drags the other side along. We will see him frequently converting bilateral activities into unilateral activities. When he must use both sides of his body, one side will definitely lead and the other will follow without taking a positive part in the performance. When writing on the chalkboard, this child also writes with his dominant hand, but the opposite hand and arm hang limply at his side, almost paralyzed.

It is revealing to note that Kephart considers complete unilaterality to be a rather severe handicap, while Delecato, et. al. suggest that this is a goal devoutly to be desired.

Kephart (66g) says: ... "directionality in space is the projection outside the organism of the laterality which the individual has developed inside the organism. This leads us to postulate that poor directionality stems from poor laterality and this in turn is likely to be associated with inadequate body scheme or awareness. "If laterality is not established in the child, and if the directionality resulting from laterality has not been developed, then certain relationships in space will be meaningless. Without laterality, there is no difference between a 'b' and a 'd'. It is not that the child is confused; it is not that he has not learned the difference; it is not that he reverses the letter. The fact is, that for this child no difference exists at all between these letters. The only difference between a 'b' and a 'd' is a difference in direction, and for this child no directions exist and therefore no differences in terms of directionality can exist. It is fruitless to attempt to teach the child the complex activities involved in reading as long as he continues to lack this basic skill."

Schrock (93) points out that spatial objects that are completely symmetrical do not have a right or left side. It is only objects that have asymmetries that can have a consistant right and left side. Once again, we have an illustration of Gesell's functional asymmetry! We can consider an asymmetrical object, having a front and back, top or bottom and right and left as having intrinsic directionality. A perfectly symmetrical object, having no front or back, top or bottom or right or left has directionality only when it is arbitrarily assigned to it by the observer. The arbitrary directionality may be termed, extrinsic directionality. Our bodies have intrinsic directionality by virtue of their top and bottom, front and back and right and left; only by reference to this intrinsic directionality of our bodies can we consistantly assign directions to such objects as "b" and "d" and "saw" and "was".

Gesell (51c) states, "Motor ineptitudes may arrive out of exaggeration of defects in this process of reciprocal interweaving...The different modes by which children learn to walk and run are impressive for variety of style ...and often a style of acquiring motor control pervades other fields of behavioral adaptation." Jones (94) and Harris (95) conclude that a difficulty in laterality may cause academic difficulty and that the child must be given an opportunity to develop these abilities before he is required to perform tasks which are too demanding for him.

It will be seen that in view of the uncertainty in determining the dominant hand and foot, the bilateral representation of either eye in both hemispheres, interhemispheric connections, the possible influence of the mother tongue on the locale of the language hemisphere, the unpredictability of the language hemisphere in sinistrals, the need for a functional asymmetry preceded by periods of bilaterality and the biological inadequacy of complete unilaterality, that the stress placed by the workers from Orton to Delacato is quite unrealistic. In fairness to Delacato and his colleagues, it must be noted that he does recognize the need for periods of bilaterality before unilaterality is achieved. In his books he also stresses the need for oculo-motor facility and tactual and kinesthetic enhancement, but is seems that a little knowledge is a dangerous thing, and the lay and professional people reading his works seem to have come out with crawling for the sake of crawling and complete, blind, unreasoning insistance on unilaterality of eye, hand and foot.

The child must possess a sound body image, a good sense of intrinsic laterality and spatial directionality. He will, of course, as phylogenetically determined, have a preferred hand, but this hand need have no relationship to any cortical center. If there is any significance to having physical contiguity of the language center and the visual and motor control, this might be obtained by training perceptual-motor skills in the right visual hemifield. There is no justification for occluding one eye, tying down one limb, stressing unilateral physical activities or any other perversion of man's ability to efficiently cope with a constantly changing environment. (96)

It may serve to clarify the waters muddied ever since Orton's work concerning strephosymbolia, neural confusion, (97) cross dominance and motor integrade patterns if we realize that these clinical entites are all symptoms of a more general problem. The underlying problem in all these conditions is a lack of extrinsic spatial directionality which is the result of poor intrinsic laterality, which in turn has been caused by an inadequate appreciation of body image. Thus, as in any other condition, one or all of these symptoms may coexist. A symptom does not cause another symptom; cross-dominance does not cause neural confusion, nor does neural confusion cause strephosymbolia.

The successes reported by Delacato are probably due to the valuable stress placed upon gross motor activity, although it is likely that the energy expended in creeping and crawling would result in more meaningful learning if visual guidance and observation and spatial judgments were added to his routines so that there would be a synesthesia of all the senses as in the normal developmental locomotion of the infant. The use of the stereoreader and cheiroscopic work may have also aided in the stabilization of binocularity and a fortuous reinforcement of right hemi-field visual input.

THE SPEECH-AUDITORY SYSTEM

Piaget (98, 99) discusses the developmental trend of language from an egocentric or subjective speech to a socialized or objective communication. This shift from self outward parallels the shift in movement and manipulation of self outward to the visual appreciation of absolute and relative spatial localization.

Kephart (50c) and Lyons and Lyons (100) give lucid descriptions of the development of language. The baby starts with babbling, which is essentially vocal play. The child produces sound to which no meanings are attached and continues to produce them solely for the pleasure of muscle feeling and auditory input which they give him. He is trying out his lungs, vocal cords and speech muscles.

At the age of six to twelve months, the child moves his lips and tongue rythmically repeating simple syllables and the feeling of mouth and tongue movements. This is the period of echolalia and sets up a number of circular reactions. When he repeats a syllable, he stimulates himself kinesthetically and auditorily. During this process, he establishes a feedback mechanism whereby his speech production, with its kinesthetic-tactual stimuli becomes connected with his auditory perception and he learns to match the two. This provides the motor basis for future speech and a check against auditory perception.

The child then begins to verbalize his perceptual processes as they occur; he uses language in order to maintain the orderly succession of his perceptions. As the naming or labeling stage of language progresses, the child notes similarities and differences between objects. Labeling is considered a gross sort of classification into groups, and of course centers around the use of nouns.

"The word stands directly and completely for the object and serves only to substitute for the object...The language and the perception are the same thing."

The child next uses verbs to denote action, movement or existance in his space world. As his language develops, he moves from Piaget's egocentric or subjective communication to the objective, or communication with others. He finds that he is able to share his percepts with others and they are able to share their percepts with him.

Language becomes a short circuiting system to help the child formulate his own experiences and gives him an opportunity for learning through the vicarious experiences of others. Another step in the efficient interaction and exploration of his environment has been made. The use of language minimizes the necessity for movement, manipulation and visual explorations.

Without an adequate space world in which to locate objects and in which to observe their relationships with one another, our whole concept of external reality and causative factors in our environment would be next to impossible. To make comparisons between objects we need a stable and extensive space world so that objects for comparison can be held in the mind while the relationships between them remain stable. By labeling the percept with a word and speaking this word, the child is able to make a percept reversible and usable over and over again. With a word, we can anchor a percept and combine and recombine it with another percept as we need.

Symbolic efficiency enables us to use symbols, be they spoken pictorial or written to RE-PRESENT the percept to us. The sound or sight of the word call forth all the associations that the original object in time and space elicited at the first presentation. (2)

Barsch (2a) suggests that language is essentially a symbolic representation of space; in speaking or reading we are trying to match our spatial world to that of the speaker or author. As an example of how the various parts of speech convey our performance in space, he lists:

(a) Noun - What is out there in space that is different from all other objects.
(b) Verb - A change in location in space through movement or the existance of something in space.
(c) Preposition - Something in front of a thought.
(d) Adjective - Differences in size, shape and form.
(e) Parsing - The temporal sequence of action in space.

Kephart(79b) states: "As in the development of spatial relationships, so in the development of temporal relationships may children experience difficulty. As a result, they have difficulty organizing events in time and they have particular difficulty with our educational material in which temporal sequence is vital." Words, for example, have temporal as well as spatial characteristics. The sequence of letters in a word is one of the characteristics of a word and this sequence is one of temporal as well as spatial relations.

Lyons and Lyons(100) state: "Next, the space between letters and words that he has learned to hear and say by changes in time sequence must be recognized and learned visually by estimations in spatial judgment and sequence. These two intervals of time and space must be combined in proper order before words can be read in the logical sequence of oral reading."

Arner (54) defines a percept as a "here and now" information processing and a concept as a "there and then" retention. As the child obtains a new percept he adds it to the previous body of percepts, call the concepts, and refines his concept concerning the experience with each new percept.

"Whereas a locomotor response commits the organism to a change in the organism-environment relation, the use of language can achieve the same and without such a commitment. The child can now perform numerous experiments much more quickly than he could under conditions where overt movement was involved." (50f)

"When the word has become a symbol and has been freed from its attachment to perceptual representation, the child is able to enlarge greatly his experimental activity... In studying children we shall find that their progress consists both in learning words as names, labeling or representing things, but in the growth of power to use vocal behavior as a means of supplementing and in the end, <u>replacing</u> other behavior... It is evident the higher we move in the direction of intelligent activity, the further we go away from concrete manipulation and purely perceptual activity. The process involves the substitution of systems of relationships and differences for concrete manipulation and purely perceptual activity. The process involves the substitution of systems of relationships and differences for concrete objects (50c)... The phylogenetic development of the organism has been to a large extent the story of its increasingly successful attempts to free itself from the limitations of its environment." (50g)

VISUALIZATION

We have described how the use of language and speech-auditory symbolization and conceptualization serves to aid in the rapid efficient exploration and interaction with the environment. There is an even more efficient means of environmental interaction; the ability to visualize, or "see in the mind's eye". Our language is rich in phrases describing this ability: "see", "get the picture", "look", to "point out", "from my point of view".

Funkhouser (101) gives further examples, such as: "To have ones eyes open" means to be acute or clever. The expression, "Do you see?" means to understand. "To look after", means to care for. "To overlook", means to forget, as does "to disregard". "To oversee" means to manage, if one says, "I will see about it", they mean they will find out. If they say, "I will see you through", they mean they will accomplish. If they say, "I can see through it", they mean they are not deceived.

Lyons and Lyons (100) describe the early babbling and echolalia as an <u>auditory-verbal match.</u> They then describe a transition to a <u>verbal-visual match.</u> Oral pronounciation actually becomes a hindrance to comprehension, so guidance dominated by verbal, shifts more and more to guidance from the visual field. How completely this visual shifting is accomplished depends on the degree of accuracy of matching patterns learned in the auditory-verbal-visual. If learning has been adequate and purposeful, verbal will become increasingly subordinate and visually retained symbol increasingly dominant.

These visually held symbols work as readily accessible tools for the conveyance of thought which the mind can arrange and combine rapidly without slow detouring through verbal. Because of the rapidity and lack of detouring in the process, structural units can be more readily seen and grasped, resulting in true understanding or visualizing reading and thinking. The degree of virtuosity an individual can achieve in both rate and comprehension at this level depends on the amount of ability he builds in holding visual symbols free of verbal, and establishing visualization of increasingly abstract structural relationships.

Most of the problems of either child or adult found in reading, scholastic performance, or individual area of operation, that require productive ability, can be located as errors or delays in verbal-visual matching. The difficulty may extend far back, being fairly obviously revealed in poor speech patterns, or limited auditory discrimination, or the problem may be much more diffuse, appearing as one of the evidences of poor visual recall. Such symptoms may be observable in the symbolic area alone, or also may be found in areas of activities with people, situations, directions and spatial orientation. The individual may be described as "absent-minded" or "vague" or "careless".

If the problem is recognized in the early grades, it usually appears as specific difficulty in recognizing words at sight. A reading approach based on visual recognition or "flash cards" can prove an insurmountable barrier to such children. However, a phonic program, lacking the goal of matching verbal with visual symbol; or a verbal-visual symbolizing approach built on poor visual mechanics, can prove as equally handicapping in later achieving visual shifting.

Many children in secondary schools, when tested on silent reading may turn in fair scores on rate and comprehension, since silent reading permits skimming for general context. If requested to read aloud, however, they may be found to be seriously confusing words similar in appearance. They tend to omit or misread small words that completely change the meaning of the text. Their confusions in meaning may even extend to words sounding similar but having different meaning.

Spelling is characteristically a major problem with reversals of vowels and consonants frequently appearing within a word or vowels inserted between blending consonants. These errors quite frankly reveal their inaccuracies in matching spatial postion and timing. Many have more difficulty with smaller words learned as "sight words" in early school years, than with words learned in elementary grades by rote auditory memorization, pointing out their inadequate "visual readiness" in beginning school grades.

Not until late high school years do many students become actively aware of their problems. These youngsters generally have acquired adequate vocabularies, are able to read individual words with accurate pronounciation and accenting, but complain of difficulty in gaining meaning from long paragraphs and articles. Their phrase reading is usually poor, tending to be word by word readers.

Understanding of grammatical sequence or syntax (such as visualizing and associating subject and predicate, without being misled by subordinate intervening words) is vague. Visualization of directional orientation and such concepts as time, space and causal relationships is generally grossly impaired. They thus fail to gain meaning and significance from words conveying these concepts that act as joining instruments in sentences such as while, when, during (time); where, here, there (spatial); as, because, for (causal). By failing to visualize the important thought in the short line of the sentence, the meaning of the "longer line" or paragraph, becomes increasingly obscure.

If whatever form the difficulty appears, we know these individuals must be taught a new level of performance - that of the visual. The success of such learning is dependent first on effectively functioning "visual machinery". Such functioning can be established by the basic and fundamental steps of optometric visual training. We have stated that true visualization is a process of learning by actual understanding of the inherent nature of a problem, whatever the problem may be."

An interesting observation is reported by Critchley, (91g) who suggests that literary work demanding a particularly high level of performance, such as expected by a professional writer, is strikingly affected in disease of the minor hemisphere mediating visualization.

PERSONALITY, EMOTIONAL RELATIONSHIPS AND PERCEPTUAL-MOTOR SKILLS

There is a large body of literature which suggests that personality, emotional disturbances and psychiatric disorders varying from slight neurosis to severe psychotic states are related to the information processing modes of the individual.

Bender (67) suggests that there is a close relationship between physiological and psychological development; she also stresses the body image problems of brain damaged children in this light.

Schneider, (102, 103) Witte and Roote, (104) Schultz, (105) and Bently and Springer (106) imply some relationships between visual functions and emotional disturbances. Gellert (71) also suggests that body image concepts may be related to schizophrenia and other behavioral impairments.

Brown, (107) Zuckerman and Levine, (108) and Zuckerman, et al, (109) suggest that the effects of sensory deprivation on emotional states imply a dependence of personality on perceptual-motor information processing.

Johannsen, Friedman and Liccione (110) found some visual perception impairments as a function of chronicity in schizophrenia and Miller and Kemp (111) found some support for the hypothesis that groups of expansive and restrictive people, selected on the basis of gesture, speech and other affective behavior, would generalize their styles of visual perception.

Hollen (112) suggests that children classified as "autistic" lack a concept of "I" or self. Other similar characteristics of these children are a lack of visual space processing, impaired speech-auditory communication, poor special motor control, confusion in laterality and directionality, poor body image and poor general motor coordination. It is interesting to speculate in view of the observations mentioned earlier of the effects of sensory deprivation in both adult and infant, which came first - the psychiatrically defined diagnosis of autism or the impairment in perceptual-motor development? It is possible that the withdrawn, non-communicative aspects of these children are more a symptom than a cause of their inability to interact with their environment and use normal communication channels because of perceptual-motor inadequacies. (113a)

It is also of interest to note that these children may be "reached" only when they are put into action or movement, such as throwing or catching a large ball. It would appear that a fruitful approach to these children, as well as those variously diagnosed as "perceptual-motor handicapped", "educable mentally handicapped", "trainable mentally handicapped", "retarded" or "brain damaged" might be through a sequence of developmental guidance based on movements and action.

At present, such children are placed into a special classroom. The administrator, who usually knows nothing about learning disabilities, is happy to know that the psychologist has declared the child to be "one of those" and has provided him with a permanent solution to the problem...Such an approach implies a limited and stabilized level of performance...we as educators have no right to make such an assumption about any child until all known means for solving that child's learning disability have failed! (113)

Certainly all these children have more things in common than they have apart. They are all human beings, with the same need for learning the basic developmental sequences of life. Irrespective of the label attached to them, they should all be given an opportunity to attain their fullest potential. (114)

THE SENSITIVE PERIOD

Montessori (60c) describes a sensitive period, during which the learning of any specific skill is best accomplished. McGraw (115) suggests, "Critical periods occur in the growth of any phenomena when it is most susceptible to definite kinds of stimulation. The critical period for one activity may occur at one time in the life of the individual and at another time for a different activity. The major factor contributing to an alteration in behavior may at one time be the status of neurostructural components, at another time, variations in anatomical dimensions, and at another time, personal or individual experience."

By the time a baby is born he has already probably developed all of the brain cells that he will ever have. Brain growth after birth consists primarily of an increase in the size of the cells and in the number and complexity of the axons and dendrites. These postnatal increases occur first in the areas of the cortex that control movement, then in the sensory areas, beginning with those that govern the sense of touch. The vision and hearing areas develop somewhat later. (84)

In the course of development, many cells are capable of assuming a variety of function depending upon local condition. Similarly, for any one function, a variety of cells are available which can be differentiated to perform this function. Later in the developmental cycle, the number of alternatives for any one cell is reduced, eventually to the point where only one function is open to it." (50h)

These references and others (114, 116) suggest that there is a period of optimum receptivity (54) during which there is an ideal combination of undifferentiated brain cells, physiological and anatomical plasticity and previous development, which when given an opportunity to interact with the environment, will result in the most efficient and effective learning of any skill.

Once the child has passed the age of optimum receptivity for this developmental attribute and the brain and other systems have been committed, spontaneous learning will not occur no matter how long the child lives, if he does not receive help.

This hypothesis suggests that children must be given maximal opportunity to interact with their environment from the moment of birth; opportunities once lost, are difficult to regain.

DISCUSSION

We have attempted to show how the progress of man from a hominoid using an eolithic tool, through the phases of early tool making, the development of language, the emergence of "civilization", the development of writing and the discovery of history and of temporal causation has been accompanied by a progressive evolution of anatomical, physiological and neurological factors.

We submit that the goal of man's evolutionary process has been to free him from the restrictions of his environment. His erect posture freed his forelimbs for manipulation and inspection. The evolution of his visual apparatus permitted him to inspect space at a distance and dispense with sniffing and touching every object of interest. The evolution of an asymmetrical brain enabled him to process information from right and left worlds and permit the development of a directional sense.

Language and communication and later writing and symbolic representation further freed man from the limitations of personal experience and contact. The use of symbolization and conceptualization reaches its highest form in the ability to visualize. With visualization, we are able to inspect our environment without moving through it, without touching it, in fact, without even seeing it. We are freed of the limitation of space and time and concrete reality. Imagine Einstein evolving the General Theory of Relativity, if he had to locomote to and manipulate or see every facet of his investigation. Clearly, the highest form of man's creativity, be it art, music, literature, or scientific discovery and application. is dependent on the evolved ability to visualize.

The ontogentic studies indicate that the ability to visualize evolves out of the ability to verbalize with symbol and concept. The abilities to visualize and verbalize evolve out of the ability to process information through the speech-auditory system, and at the highest level of environmental inspection, the visual system.

Visual inspection and interpretation of space evolved out of skilled and subtle eye movement control. Eye movement control is dependent on special or fine motor control, and the transition from tactual inspection and manipulation.

Tactual manipulation and visual inspection could never have evolved if the organism were unable to locomote itself through space, which in turn requires antigravity control and the maintenance of erect posture. Without body image and schema, learned through movement, we could not orient ourselves in space with any consistancy of directionality.

It will be seen that there is a sequential process, in which each level is dependent on the smooth and efficient mastery of the preceeding level. (82a, 49b) At all levels, as we progress up the ladder of sophisticated environmental interaction, we note that the amount of movement and overt activity diminishes. The infant displays the grosses most generalized and undifferentiated movements in an attempt to explore his crib; and Einstein could sit, silent and immobile and explore the universe.

Montessori (60d) again stated, "The analysis of movement is bound up with the economy of movement; to perform no movement unnecessary for the purpose is really the highest degree of perfection."

From these considerations, we may evolve two maximums of effective and efficient behavior:

(a) Immobility - the highest form of movement control is to be immobile.

(b) Silence - the highest level of communication is silence.

To illustrate the first goal, immobility, consider the Law of Parsimony, which states that biological efficiency consists of accomplishing the task with the minimum of effort; don't move the whole arm when the little finger will do. The hyperactivity reported by Cohen (85), Cohen (117), Cruickshank (118) and Strauss & Kephart (50i) is simply an example of poor motor modulation and efficiency.

As an example of the second goal, silence, consider the two friends who can communicate by a glance or gesture, word or phrase the same information that would take two other people an hour of vague, unspecific verbal interchange. One of the attributes of a good vocabulary is the ability to use just the right word to communicate the thought instead of an entire paragraph.

A. Organizations of perceptual-motor-cognitive performance.

Getman (49b) has organized the developmental sequence under the headings of:

(a) The development of general movement patterns <u>for</u> action.

(b) The development of special movement patterns <u>of</u> action.

(c) The development of eye movement patterns to <u>reduce</u> action.

(d) The development of communications patterns to <u>replace</u> action.

(e) The development of visualization patterns to <u>substitute</u> for action, speech and time.

It will be seen that this paper has essentially followed Getman's outline as a frame of reference.

Kephart (79) divides the basic maturational skills into:

(a) Balance and the maintenance of posture.

(b) Locomotion.

(c) Contact.

(d) Receipt and propulsion.

Barsch (2) lists as the Dimensions of Human Performance:

(a) Transport-Orientation
  1. Who am I?
     -muscular strength
     -dynamic balance
     -body awareness
  2. Where am I?
     -spatial awareness; the x, y, and z axis
  3. When?
     -temporal awareness

Failure to learn the operational modes may result in a child denoted as a "special education" problem.

(b) Percepto-Cognitive Systems
  1. Gustatory
  2. Olefactory
  3. Tactual
  4. Kinesthetic
  5. Auditory
  6. Visual

The visual system is a recapitulation of and replacement for the other systems, and is the highest form of organization. Failure to master these modes of information input may result in the typical grade school and high school failure.

(c) Bilaterality

1. For all the body pairs, except hands

Failure to establish a firm sense of laterality and directionality may result in the college failure.

(d) Rhythm

(e) Flexibility

(f) Motor planning

It will be seen that these three men, together with others such as K. U. Smith (1) have similar approaches to the problem of "learning how to learn", or the development of what is frequently referred to as "academic readiness". They have in common an initial emphasis on movement, with its implication on body schema or awareness, locomotion by early movement and the visual inspection of space as the epitome of the developmental sequence. They imply the ability to process on the completely symbolic or visualization level is the ultimate goal of man's cognitive evolution.

The various perceptual motor and perceptual cognitive systems developed in this paper may be studied only by observing the total performance of the individual. We cannot isolate one test or measure of a single performance variable and claim to have more than a small sample of the performance characteristics of the individual. We must evaluate all the modes of information processing under a wide variety of conditions and relate these observations to some frame of reference and expected performance levels. It is not so much what is done, but how it is done that enables us to evaluate performance.

B. Evaluations of Performance.

The work of Getman (119) and the staff of the Optometric Extension Program Section on Child Vision Care and Guidance list an approach to what may be termed a developmental evaluation. Radler and Kephart (120, 59) list a similar approach and Woolf (121) describes the performance characteristics of visual problems under the heading of the visual disability syndrome.

The precise testing technique is not critical; it need only be as formal and complete as the needs of the examiner. It should, however, include some observation and evaluation of the basic developmental sequence:

1. Gross motor ability:
   (a) The ability to move through space in any manner and in any direction.
   (b) Adequacy of body image or schema.
   (c) Laterality, directionality and reciprocal interweaving of rights and lefts, tops and bottoms of the body.
2. Special motor ability:
   (a) Manipulative ability of hands, and of feet, if desired.
3. Eye-hand relationships:
   (a) The efficiency and accuracy of eye monitoring of hand movements.
   (b) The level used in the performance heirarchy of:
      -tactual
      -tactual-visual
      -visual-tactual
      -visual
4. Oculomotor patterns:
   (a) The ability to rapidly and efficiently inspect the world with consistant and precise eye movements.
   (b) The ability to change the focusing level of the eye with rapidly changing locations of the task.
5. Visual judgments of space, size and form.
6. The speech-auditory level of symbolic manipulation and concept formation.
7. The visualization level of symbolic manipulation and concept formation.

Experience will permit the examiner to obtain an overall profile of the preferred information processing modes of the individual. Again, the interest is less on what is done, than on how it was done. It will be found that difficulties in one mode will frequently be reflected or repeated up and down the line. We will be interested in learning the individual's most efficient modality; does he communicate or interact best on the visual level, the auditory level, the tactual level, or the kinesthetic level? Henry (122) describes how these performance levels may be observed in the sophisticated adult as well as in the naive child.

Lowenfeld (123) describes two extremes of information processing, the visual and the haptic or tactual-kinesthetic. "A visually minded individual would be disturbed and inhibited if he were to be stimulated only by means of haptic impressions-that is, if he were asked not to use sight, but to orient himself only by means of touch, body feeling, muscular associations and kinesthetic fusions." So much is clear, but what is not as obvious is that "seeing" may also become an inhibitory factor when forced upon an individual who does not use his visual experiences for creative work.

An extreme haptic type of individual, who is by no means rare, is normal sighted and uses his eyes only when compelled to do so; otherwise he reacts as would a blind person who is entirely dependent on touch and kinesthesis.

<u>Most people fall between these two extreme types.</u> In a study...47 percent were clearly visual, 23 percent were haptic and 30 percent were not identifiable. The electroencephalographic studies of Walter (124) also tend to confirm these observations.

We may include the other type of individual, the auditory learned. Spache (24) reports several studies have been successful in differentiating the different performance types and Barsch (2a) suggests that a careful analysis of convential psychomotor and intelligence testing may also be utilized to reveal the individual performance characteristics. He suggests that the normal sequence would be kinesthetic, tactual, auditory, and then visual. He also points out that the educational curricula and facilities of our school systems place a high premium on visual and auditory input, and a child with any sequence other than visual-auditory-kinesthetic and tactual must experience learning difficulties in the classroom.

C. What to do about the problem.

The beauty of the evaluation rationale described is that the criteria and terms used are at the same time both diagnostic and therapeutic. If a child is found to be deficient in gross motor abilities, then clearly, training must include gross motor activity. A deficit in good oculo-motor ability would naturally imply training in this skill. The labels applied to various learning problems by many educators are to be commended for their diversity and complexity, not for their implied remedial aspects.

The training will naturally follow normal developmental principles. Just as ontogeny may recapitulate phylogeny, so must developmental guidance recapitulate ontogeny. The child must be brought back to the lowest developmental level at which an inadequacy exists and be brought forward, step by step, as his abilities will permit. In general, it will be found that most performance problems stem from the early movement patterns and body schema inadequacies. Therefore, in most cases, the training will begin on the basic levels in any event and progression will depend on how rapidly the child can integrate and generalize his learning.

The basic concepts of Gesell, cephalo-caudad progressions, proximal distal or gross to fine, reciprocal interweaving of all modalities and multi-sensory integration will serve as guideposts. The statements of Montessori, Getman, Ayres, Gesell, Barsch, and Smith concerning the need for synthesis and flexibility of performance must be stressed. We must be careful to avoid drilling "parlor games" or isolated splinter skills; generality and integration must be the goal.

Ayres (82) lends support for approaches to visual perception training that involves gross motor activities. Smith (1) states, "All children, especially those with behavior disabilities, would benefit from extensive practice or training in space organized motion patterns. In addition to creeping and walking, other large motions, such as bending, stooping, reaching, throwing, etc., might be used to enhance postural control and bilateral co-ordinations. The idea is to train those movement components that serve as up-down and right-left reference systems for finer co-ordinations. If development of these basic movement systems has been interrupted or retarded by disease or some other disturbing factor, intensive training as postural or transport control may be needed before manipulative and vocal co-ordination can develop to a satisfactory level. Of particular interest here are possible interactions between emotional and physiological states and organized psychomotor behavior.

The teaching of specific skills or knowledge must be adjusted to the phase of development as defined by the level of maturation of the sensorimotor feedback mechanisms. Wherever possible, teaching and training should be adjusted to the pattern or differentiation and integration in the particular child. The child can learn new responses only to the degree that his present level and patterns of development provide him with the response-regulated feedback control of the physical and social features of his environment. Thus, teaching and training design should be adjusted to the level of control already achieved, but also should be sensitive to the potential changes in response organization that may come in due time through maturation.

The development of sensory control is essential to maintain motivation, both generally and specifically. We have seen that sensory deprivation not only disturbs specific aspects of development, but can act as a general stress factor. Further, at certain critical periods, special forms of stimulation influence development and subsequent learning, and very likely affect motivational patterns. Thus, it is likely that adjust motives and attitudes are influenced by the presence or absence of certain kinds of sensory experience at critical periods of development when particular forms of feedback control are emerging.

There is strong suggestive evidence that the early development of many symbolic skills, including mathematical operations, is related to patterns of bilateral co-ordination during childhood. Thinking involves many forms of symbolic control, both verbal and non-verbal that appear during the period when bilateral control in psycomotor or activities is developing. In our opinion, this correspondence reflect of common origin of symbolic control and complex psychomotor control in the development of the basic movement systems and their integrating through maturation and learning. Symbolic responses are differentiated out of direct responses; implicit symbolism is a refinement of overt symbolism. Thinking represents no radical new form of behavior organization or control, but is differentiated gradually from other kinds of responses.

A basic principle of training is to perturb the feedback properties of response systematically in order to provide the learner with opportunities to extend his understanding and control of his own actions in relation to the environment. Common skills such as writing and drawing should be carried out with different instruments and using different parts of the body. For example, a young child can be taught to make the letters of the alphabet with his body and limbs, or by large body actions. These larger actions patterns will extend his understanding and control of the letter forms and will facilitate the fine manipulative control which must be learned later in writing.

Barsch (125) has worked with these concepts for some years and reports considerable success with normal and brain damaged children. The program is called Movigenics. It is based on the concept that movement is a constant in the living organism, and must be co-ordinated. The individual must process information and must move in response to that information. The distortions, deviations, warps and confusions and maladjustments of the individual become explainable in terms of movement failures.

A study reported by Argy (126) in which two matched groups of children were taught by orthodox and Montessori techniques resulted in significant improvement in developmental quotients, alertness, responsive interest in the surroundings, power of concentration and language formulation and expression. Spache, et. al. (127) also reports that a group of children with inadequate readiness showed marked gains in reading and academic performance after a program of perceptual-motor training and little or no formal academic work. Simpson and others report similar results. (128)

Hebb (86b) postulates two kinds of intelligence. Intelligence A is the innate potential; a good brain and a good neural metabolism. Intelligence B is the functioning of a brain in which development has gone on; that which is normally measured and observed. He goes on to suggest that experience and interaction with the environment is essential for the full development of Intelligence B, summarizing by stating, "There are then two determinants of intellectual growth; a completely necessary potential (Intelligence A) and a completely necessary stimulating environment."

We have attempted to provide a rationale for developmental testing and training by providing the psylogenetic implications and ontogentic requirements for the fullest realization of our potential to effectively and efficiently interact with our environment. Through sensitivity and awareness to the characteristic learning modes of children we may better be able to understand why many children have difficulty in learning and hopefully help them learn how to learn.

SUMMARY AND CONCLUSIONS

1. The phylogenetic development of man has resulted in an anatomical, physiological and neurological potential for environmental interaction in a highly efficient symbolic and conceptual manner.

2. Since ontogeny may recapitulate phylogeny, the child must be given every opportunity to explore and interact with his environment, so as to develop his basic endowment to its fullest potential.

3. There is a sequential learning process for the perceptual-motor-cognitive abilities of man, and for each developmental level there is an age of optimum receptivity during which the attribute may be learned spontaneously.

4. If the age of optimum receptivity and spontaneous learning has been passed, performance difficulties may remain unless guidance is provided.

5. Movement as the basis for perception is stressed and symbolic manipulation and visualization as a means of reducing movement is recognized as the goal of developmental efficiency.

6. Development guidance must recapitulate the normal learning sequences of childhood; just as ontogeny may recapitulate phylogeny, so must developmental guidance recapitulate ontogeny.

7. Implications of developmental inadequacies in perceptual motor skills in adults, emotionally disturbed and mentally handicapped children are discussed.

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