MINIMUM ATTENTION MODEL FOR UNDERSTANDING THE DEVELOPMENT OF EFFICIENT VISUAL FUNCTION

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ABSTRACT

Vision in its broadest sense involves three basic processing areas. Firstly, the sensory coding of the light distribution on the retina; secondly, the central processing in the brain of the information from the eyes; and thirdly, the consequent eye muscle control of eye movements.

While innate factors provide the essential ingredients for visual function, it is the developed components that determine the efficiency of visual information acquisition and processing.

A "minimum attention" model for understanding how these abilities (schemata) emerge and organize to subserve visual performance is described.

This model suggests two classes of visually-related reading disabilities. Seven commonly observed areas of visual dysfunction are discussed. When a child has inadequate ability in two or more of these areas, significant difficulty coping efficiently with the visual demands of the classroom can be expected. The relationship between visual abilities and educational performance suggests two classes of visually-related reading disabilities.

An approach that can be adopted by optometrists wishing to programme preventive vision care for children will be outlined.

KEY WORDS

minimum attention model, schema, automaticity, visual perception, visual cognition, preventive vision care, vision

The physiological status, refractive status and eye health of a group of young 6- to 12-month-old children soon demonstrate that most have:

a. little or no lag on nearpoint dynamic retinoscopy
b. nearpoint of convergence to about 4-6 cms. from the nose
c. the expected visual acuity of about 6/6
d. no significant deviation on cover test
e. no significant refractive anomaly
f. healthy eyes—with full and concomitant motility

It seems appropriate to now ask: "What is left to develop?"

Obviously the child must now develop the capacity to apply visual function. That is, he must develop VISUAL ABILITIES for efficient acquisition and processing of information during problem solving and dynamic behaviour.

THE MINIMAL ATTENTION MODEL

Vision in its broadest sense involves three basic processing areas.

Firstly—the sensory coding of the light distribution on the retina of each EYE.

Secondly—the BRAIN, where the central processing of information occurs and the conscious decisions for Selective Attention are made.

Then, thirdly—the MOTOR OUTFLOW which is orchestrated by the brain and involves eye movements and the accommodation/convergence synkinetic coupling.

Thus, the retina in each eye codes the relative spatial distribution of contrast from the optical image of the environment and also specifically detects movement of any part of the image. The processing within the brain requires the comparison and integration of this information with information from the other sensory systems to form a composite representation of the environment around us. The images from the two eyes are fused together to form a single percept and also comparison of the minute differences in the images from each eye provide direct information about 3-dimensional depth. Analysis of relative size, overlapping contours and relative motion parallax provides further clues to the structure of the environment. The visual perception and interpretation of our environment is tempered by the information from our other sensory systems and our past experience. These perceptual and cognitive processes lead to a motor response in reaction to the environmental input. If attention is directed towards a component of the environment, then usually the eyes are moved to establish fixation on the object of interest. Fixations for precise visual inspection involve both accommodation and vergence muscle actions.

If attention is maintained, the oculomotor system will maintain fixation using smooth pursuit eye movements despite object and/or head and body movement. The vestibular and muscle proprioceptive systems integrate with the visual information to maintain this stability of fixation.

If attention is directed towards another feature or object then a fast saccadic jump eye movement can be used to establish the new fixation with appropriate accommodation and convergence correction.

This whole system is under feedback control in that the system is continually monitoring the sensory input to check the accuracy of the oculomotor responses in relation to the demands of the task. One of the difficulties in analysing and understanding a feedback controlled system is that it is difficult to localise dysfunction to one particular component of the system unless you can first break and loop in some way. Deficiencies in any or all of these three basic areas of visual processing can result in overall visual dysfunction.

A simple demonstration can be made to illustrate how the conscious decisions within the brain determine what posture is assumed by the accommodation mechanism. Thus, the quality of information from the light distribution on the retina is similarly influenced by this conscious decision. With one eye closed, holding a finger at arm's reach and aligning the finger with a distant target, it is quickly appreciated that we can choose to attend to either the distant object or the finger. We can clearly focus on whichever we choose (given that an appropriate refractive status and adequate amplitude of accommodation is available), but we can only see one object clearly at any one point in time. The object that is seen clearly is the object we choose to make clear.

Therefore: The accommodation process as applied to everyday life and information gathering is driven by conscious decisions and is therefore a self-directed process.

A second demonstration: Now with both eyes open, hold a finger at arm's length and aligned with a distant object. We are all aware that if the distant object is viewed with appropriate binocular alignment, then the finger will be seen in physiological diplopia. Similarly, if the finger is viewed with appropriate binocular alignment, then the distant object will be seen in physiological diplopia. We consciously choose where to align our eyes.

Thus:

a. A normal state of seeing could be said to be blurred/double vision—where only a very select and specific location in visible space is available as clear and single.
b. Being able to apply our ATTENTION to the area of visible space for single and clear information acquisition is basic to efficient visual function.
c. The complexity of our visual environment, not to mention the other sensory stimulation that will impinge on the observer at any point in time, makes it impossible to process all available sensory data. We must be selective and apply our attention to that information we determine to be important.

But in reality we do not seem to need to make many conscious decisions to visually inspect our environment and to visually direct our movements.

It would seem that "pre-programmed AUTOMATIC" processes operate to manage basic visual operation so that "Minimal Attention" is required for information acquisition and processing. This maximizes the attention available for information comprehension, assimilation and creative manipulation.

Research[2-13] indicates that the way a child perceives is largely determined by his self-directed sensory-motor interaction experiences. Efficient visual function depends on a complex interaction of innate factors and learned skills. Initially, during the novice performance, the conscious decisions are significantly involved in both planning and managing appropriate visual responses. But later, with skilled performance, pre-programmed automatic mechanisms for action and thinking free the conscious mind from the mechanics of the task. An important aspect of child development is therefore currently believed to be the acquisition of an increasingly more complex repertoire of task specific automatic processes.

Pre-programmed automatic processes have been suggested by many authors grasping for understanding of the brain. They have been given various names, as Figure 1 indicates.

# D.O. Hebb[2]	Cell Assemblies
# Piaget,[4] Head, Bartlett, Vernon[5]	Schemata
# E. DeBono[14]	Patterns
# J. Fodor, K. Stanovich[15]	Modules

Figure 1. "Automatic Processes"

Edward De Bono[14] explained these automatic processes as follows:

The natural and inescapable behaviour of our self-organising brain model is that it is a pattern-making and pattern-using system. That is its natural activity, it cannot do anything else. Rain falls on a virgin landscape. Eventually the interaction of the rain and the landscape forms streams and rivers. The newly arriving rain now follows these patterns. That is the natural behaviour of the system. A person blind from birth is suddenly made capable of seeing. But that person cannot yet see, for everything is a blur. It takes some time for the brain to set up patterns of seeing.

If the brain were not a pattern-making system we would not be able to read, write or talk. Every activity, like getting dressed in the morning, would be a major time-consuming task. Sport would be impossible—for example, a golfer would have consciously to direct every part of every swing. Consider the millions of people who drive along the roads every day using patterns of perception and reaction and only occasionally having to work things out. There are routine patterns of action, like driving or playing golf. There are routine patterns of perception, which is why we can recognise knives, forks and people. There are routine patterns of meaning which is why we can listen and read and communicate.

In recent papers, Howell and Peachey[1,16,17] have referred to the developed automatic processes as: SCHEMA—single/SCHEMATA—the plural. We also considered some of the current evidence that would suggest that cortical hemispheric specialisation may form the basis of two distinct cognitive strategies.[16]

One of these modes facilitates information processing as a spatial holistic gestalt; while the other provides for sequential analysis of successive temporally organized material.

I would suggest that the minimal attention model related comfortably to these concepts. If the automatic pre-programmed processes are operating correctly then minimal attention is required to manage visual information acquisition and processing. The person can quickly and efficiently utilise processing strategies that are commonly specialised in either right or left hemispheres. Simultaneous and successive processing modes become effective and readily available and subserve the processing of visual as well as other sensory information.

These processes may not be adequately served by the necessary schemata and thus fundamental developmental problems may manifest in many different sensory motor task situations, including those that have a visual component.

The major clinical implications from this model are apparent in three areas:

1. The Optometric Evaluation of Visual Abilities

The minimal attention model predicts (and clinical experience supports) that the performance of a set task may be achieved at two distinct levels. A patient may perform the task at the novice performance level—where conscious override organises and manages much of the performance. Alternatively, a patient may perform at the skilled performance level where automatic pre-programmed "schemata" take over the management of the task.

Example: Consider the following observations during the evaluation of ocular motor control abilities of three children. Each are asked to follow the tip of a pen.

a. The first child cannot maintain visual fixation. The eyes are observed to lose contact and to jerk and cord. Head movements are frequently used to perform the task. Encouragement and instruction from the optometrist does not improve performance.

Implications: The child has poor ocular motor organisation, even while using conscious override.

Diagnosis: Basic inadequacy of ocular motor control.

b. The second child can maintain visual contact and demonstrates smooth and accurate tracking of the test target. Simple questions, well within the child's ability to answer, are then asked during the testing. The child is then observed to lose fixation, or to show poor ability to attend to the verbal instruction, or poor ability to respond to the question.

Implications: The ocular motor control is being done with conscious override.

Diagnosis: Inadequate schemata subserving ocular motor control for the specific task of tracking the test object.

c. The third child performs the task with smooth, accurate ocular motor control and demonstrates that the task can be sustained with similar efficiency while answering questions that probe mental arithmetic and spelling ability.

Implications: Automatic processes are organising the ocular motor control and thus freeing the conscious mind for other tasks.

Diagnosis: Adequate schemata subserving ocular motor control for the specific task of tracking the test object.

2. The Understanding of Skilled Performance

Efficient and skilled performance is dependent on the availability of a repertoire of task specific schemata. The interpretation that we can place on a visual input is obviously determined by our previous experience and learning. An object is recognised by matching the present observations with memory of previous cognitions. The object is also localised within space-time concepts so that reliable estimations of where it is relative to other objects, where it is relative to self and what time would be needed to reach it, etc. can be made. It seems appropriate to consider that the brain processes involved in the sensory motor manipulation and cognitive appreciation of a visual input are organised as automatic programme strategies. These schemata are specific for the interpretation of a particular class of information: thus a repertoire of appropriate pre-programmed automatic processes must be available to support skilled performances.

The task specific schemata that are underlying each skilled performance include those that enable:

- perceptual organisation and the recognition of redundancy,
- conceptual appreciation of sequential probabilities,
- movement organisation for increased economy of action,
- accurate timing.

3. Diagnosis of Visual Dysfunctions

Two distinct classes of visual dysfunction are predicted:

- the DEVELOPMENTAL disorders,
- the FATIGUE/STRESS functional deterioration.

Thus the thesis proposed is that pre-programmed task specific automatic processes, "schemata," operate to enable visual information acquisition and processing to occur while minimal attention is required to manage basic functions.

Maximal attention is then available for interpreting, assimilating and creative manipulation of the information.

THE DEVELOPMENT OF EFFICIENT VISUAL FUNCTION

Visual function involves dual processing systems—ambient/focal. Fundamental to my thinking is that: "People tell eyes what to look for—eyes do not tell people what they see."

That is, functional vision is primarily a top-down process for tasks that require detailed analysis, scanning and problem solving—while it is primarily a bottom-up process for orientation, startle alertness and survival information.

Efficient visual function depends on a complex interaction of innate factors and learned skills. The innate structure and organization of the brain and the body is genetically pre-programmed. Development proceeds as this innate system interacts with the environment and schemata for perceptual, cognitive and motor function are organised and elaborated. Deficits in this development may result from either a reduced ability to program schemata or a deprivation of appropriate interaction with the environment. Some children seem to need more "experience" to learn than others. The ability to learn from experience can be considered as one of the basic factors of "intelligence."

While innate factors provide the essential ingredients for visual function, it is the developed components that determine the efficiency of visual information acquisition and processing.

When a person is "learning" to master a new task, such as driving a car, the person is both learning new facts about cars and traffic interactions as well as developing new schemata. Initially the person experiments with movement patterns and organisations that seem appropriate to the task. The conscious mind is significantly involved in planning and directing the body movements. At an early stage, just starting the car and getting into first gear without stalling is a significant achievement. When success at the task has been achieved and practised, the conscious mind is freed for attention to other tasks. The ability to drive the car is slowly organised and generalised at a lower subconscious level so that a person can use other cars as a means of transport. Likewise when a child practices playing the piano and rehearses a set musical score, the goal is to make music, and not to get finger exercise. The child achieves the status of a musician when hand and finger activity become relatively automatic and the conscious mind can access the quality of the music.

The task specific nature of schemata can be best communicated by another example. Consider what a person must do when water skiing and snow skiing. The muscle groups and the concepts involved in performing both tasks are very similar, but competence at one skiing sport does not ensure the ability to perform at the other sport.

Clinical experience would suggest that similar programming of task specific schemata are involved in the visuo-cognitive and oculomotor aspects of reading and writing.

Piaget[4] made a distinction between development and learning. He conceptualised "development" to be a spontaneous self-directed process whereby motor programming and perceptual and cognitive programming are functionally organized into automatic processes that become general mechanisms for action and thinking; whereas learning deals with the obtaining of specific skills and facts as well as the memorising of specific information.

Piaget[18] has demonstrated the way in which concepts of conservation of area, volume, mass, etc. develop for visual, tactual and proprioceptive experiences. He proposed that these experiences organise as schemata and underpin the ability to appreciate some of the basic concepts in mathematics.

Vision is unique in being able to provide information about the spatial organisation of the environment beyond arm's length. The perceptual and cognitive interpretation of this information must presumably develop with experience. It is reasonable to argue that this development may occur by a process of comparison and matching of vision with spatial information from other sensory systems. An infant may look, shake and listen, feel and mouth an object before being satisfied that it has been explored. Thus it would appear that the sensory systems are used together to reinforce each other in the development of integrated schemata. Development leads to each sensory system being cognitively independent of the need for consensual confirmation. The child must learn to rely and trust its interpretation of the visual information without the need for tactual/kinesthetic reinforcement. This achievement of vision as an independent operating system can be seen as a higher plane of development. This concept of the development of vision independent of touch, etc. has been addressed by Gesell et al,[3] Getman,[19] and Birch.[20] In a child who has not developed an organisation of sensory systems so that vision can operate as an independent system, patterns of learning emerge which make it difficult for the child to succeed with standard classroom instruction. Children in early primary school who are considered to be developmentally delayed often exhibit this residual need to confirm vision with touch.

A simplistic overview of how schemata operate within the known anatomy and physiology can be suggested:

1. The person selects from the available sensory data the information that is wanted at higher centres for analysis and cognitive manipulation.
2. Switching stations like the lateral geniculate nucleus (LGN) receive input from higher centres as well as direct sensory input. Perhaps nuclei like the LGN act to determine what information will be selectively relayed to higher centres.
3. For a schema to be established, it would seem necessary to achieve the functional wiring of the required brain processes. This functional circuitry would enable selective attention to be placed on the appropriate sensory input, while appropriate motor organisation and appropriate cognitive associations occur. All this could then "happen" with minimal demand on conscious processes.
4. Inappropriate organisation of the functional neurology could be expected to result in the dysfunctions common to many children in the L.D. population and could explain:
   a. disturbed EEGs.
   b. unstable eye fixation.
   c. poor balance to simultaneous/successive processing.
   d. poor comprehension.
5. Developmental visual disorders result from inadequate schemata development. The treatment indicated is visual training and to provide the patient all the opportunities to develop improved abilities in the areas of inadequacy.
6. Fatigue/Stress/Cognitive demand can interact to cause visual dysfunction (schemata breakdown).

For some (the H2 Syndrome described by Howell at COVD 1990 and in "Behavioural Optometry, Vol., 3, No. 1, Jan/Feb 1990), visual training would be considered a secondary treatment and directed at the rehabilitation of the broken down schemata that do not rebound after a period of stress reduction. Visual training also can extend, elaborate and increase the robustness and stamina of schemata supporting visual function. Conceptually this would be expected to reduce the risk of regression.

For others (the H1 Syndrome described by Howell at COVD 1990 and in "Behavioural Optometry, Vol. 3, No. 1, Jan/Feb 1990), visual training would be required to help them reestablish a spatial construct necessary for their utilization of lens therapy.

7. Other causes for schemata breakdown could include traumatic brain injury, certain disease processes, poor diet and even toxic chemicals in the environment, accidentally or intentionally acquired.

WHAT ARE THE SCHEMATA OF OPTOMETRIC IMPORTANCE?

Clinical experience has shown that within the "learning disability" population there are a number of commonly observed areas of visual dysfunction which impact on the student's ability to acquire and process visually presented information. A child who has inadequate ability in two or more of these areas is most likely to have significant difficulties coping efficiently with the educational demands of a classroom.

These areas of visual inadequacies include:

1. Inadequate schemata involving visual cognitive problem-solving styles:
   When a person is engaged in a visually based problem-solving task, there is usually an abundance of visual and other sensory stimuli available. How a

person selects what to attend to and organises an appropriate visually-directed response is influenced by previous experience with similar tasks. Two of the cognitive styles that have been extensively studied are impulsivity and reflectivity. Children who are especially fast decision makers and who make many errors are often referred to as impulsive. The relationship between these styles and school achievement has been reviewed by Cron et al.[21] and they conclude .... "The data presented in this literature review clearly support the view that a child's cognitive style can be changed or modified into a more reflective approach ...."

Children typically become more reflective with age. Underachieving children, when compared to normal achievers, tend to be more impulsive in their cognitive style. The child who does not allow suitable time or scan during visual inspection and does not reflect upon the different solution possibilities is likely to implement mentally or motorically the first idea that comes to mind. This maladaptive cycle may become entrenched with time. Impulsive selection of inappropriate solutions leads to failure at the task and concomitant anxiety; a second or third inappropriate solution may also be trialed. Frustration and failure may cause the child to gradually withdraw from problem-solving situations and not attempt to learn new strategies at all.

Another way in which children differ from one another is in their organisation of their sensory systems. The developing child is usually observed to gain an increasing ability to extract information from the environment via visual function alone. That is, the sensory systems are organised so that visually acquired information becomes the primary determinative avenue through which behaviour is organised and the other sensory stimulation becomes background. Inadequate development of the schemata needed to organise the sensory systems and for the visual system to operate independently "as if" other sensory systems were in support can be expected to lead to patterns of functioning which are inappropriate for the development of reading skills.[22]

Behavioural signs that may indicate inadequate visual cognitive problem-solving style include:

- poor attention to visual detail—guessing
- seems to frequently repeat the same errors of visual discrimination
- rapid, poorly considered responses—no time taken to think
- tends to escape, withdraw or be passive in problem-solving task
- returns to "drawing with fingers" to decide likes and differences
- "feels things" when possible to assist what would usually be a visual interpretation
- poor ability and/or infrequent use of visual imagery
- frequently seems to act without looking

2. Inadequate Schemata for the Application of Direction Concepts:

A child must develop coordination abilities which enable effective movements to be made around the various body axes. The diagrammatic representation of body axes (Figure 2) illustrates how the head, trunk and eye can be subdivided into four quadrants. It is only after the child has become intuitively aware of these body axes that they can be used as references for spatial organisation. If a child lacks an internalised knowledge of these body axes, it can be expected that difficulty understanding and applying basic concepts of spatial organisation will result. Knowledge of body axes and the application of direction concepts to spatial inspections are interrelated. There is no right or left, up or down, close or far qualities within the objects we inspect. These qualities are applied to objects by the person doing the viewing after due reference is made to "body position." The child's knowledge of body axes/position develops as a result of meaningful self-directed movements where sensory stimuli, especially from visual, touch, somatosensory and vestibular are related to spatial aspects of the behaviour.

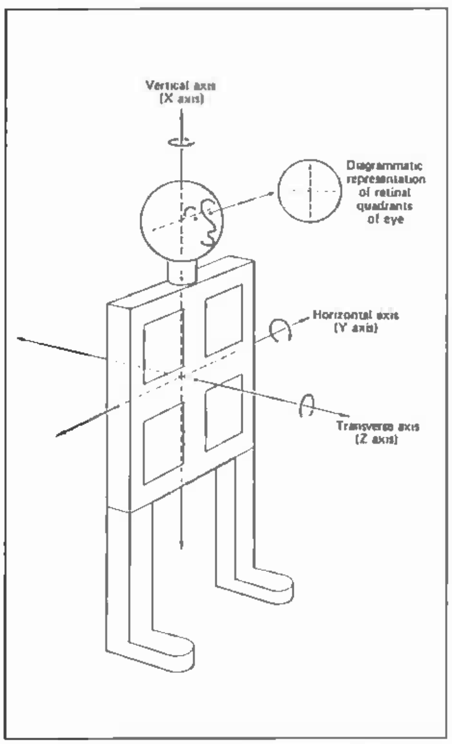

Figure 2. Diagrammatic representation of body axes from Furth and Wachs[23]

Direction concepts for abstract symbols are involved in "reading and writing." The code for letters includes a direction-orientation component which presupposes the position of the viewer relative to the letter form. Most letters are asymmetrical around their vertical axis and hence can be "mirror imaged." Some letters, such as N and Z have the same form, one being a 90 degree transformation of the other. Other letters and numbers which lead to confusion are b,d; p,q; u,n; 6,9; 5,2; V,A; M,W. When combinations of letters and numbers are used, even more confusion can emerge. For example, was, saw; tac, cat; on, no; dog, god; 13, 31, etc. Letter sequences within words can also lead to confusion and distract attention away from the "main game."

For optimal processing of visual information, directional responses should be completely accurate and automatic. Some mirror writing and letter reversal tends to occur as children first start to learn to read and write. Just as a young child will stumble and sometimes fall while learning to walk, some letter confusion and reversal can also be expected when they first enter school. "Persistent" letter confusion and reversals associated with evidence of poor knowledge of and/or control of movements around their body axes should alert parents to have their child professionally evaluated.

Behavioural signs that may indicate

inadequate directional concepts include:

- Poor body awareness
- Clumsy—poor general coordination
- Inadequate reciprocal interweaving
- Right/left confusion
- Reversals of letters, numbers or words
- Sequencing difficulty

3. Inadequate Schemata Involving Visual Form Analysis (Spatial Relationships, Visual Comparison, Visual Imagery, Visualisation)

The child's first symbols are images and pictures which allow him to mentally hold fleeting reality. This skill of visual imagery allows the child to relate primary experiences to the pictures and words seen on the printed page. Basic visual function provides global perceptual information that is available for analysis and permits the translation of object size, shape, texture, location, distance and solidarity into conscious appreciation and thinking involving language. Visual form analysis is a derived skill, not a separate and independent ability. Its ultimate purpose is the immediate and accurate discrimination of visible likenesses and differences, so comprehension can be immediately followed by appropriate actions.

Behavioural signs that may indicate inadequate visual form analysis skills include:

- repeatedly confused similar beginnings and endings of words
- fails to recognise same word in next sentence
- repeatedly confuses left-right directions
- reverses letters and/or words in writing and copying
- confuses likenesses and minor differences
- fails to visualise what is read either silently or orally
- whispers to self for reinforcement while reading silently
- returns to "drawing with fingers" to decide likes and differences

4. Inadequate Schemata for Eye-Hand Coordination

Most eye-hand tasks require the organisation of sequences of visually-guided motor movements. These sequences are usually pre-planned and rehearsed, requiring sequential analysis of the task requirements at the schema level followed by the activation of appropriate motor schema. The ability and proficiency a child may attain in this area is dependent upon the use, practice and integration of the eyes and the hands as paired learning tools. It would seem that this skill is developmentally essential and preparatory for writing and graphics that require linear-sequential thinking. The ability of a child to reproduce form which is visually presented involves the child firstly evaluating the visual form, then planning the motor sequences of hand movement that are required to reproduce that form. Many specific probes have been developed by clinicians to evaluate a child's visuo-motor integration. Tests in this area include the Gesell Copy Forms Test, the Rosner Test for Visual Analysis Skills and the Visual Motor Integration Test of Beery and Buktenika.[24]

The complex integrations of visual and tactual- proprioception must occur efficiently and subconsciously if expected progress is to occur with handwriting and graphic skills.

Behavioural signs that can indicate inadequate eye-hand coordination include:

- must feel things to assist in any interpretation required
- vision not used to "steer" hand movements (extreme lack of orientation, placement of words or drawing on page)
- writes crookedly, poorly spaced; cannot stay on ruled lines
- avoids eye-hand activities such as catching, ball play and tying laces or knots
- misaligns both horizontal and vertical series of numbers
- uses his hand or fingers to keep his place on the page
- uses other hand as "spacer" to control spacing and alignment on page
- difficulty copying from reference book and chalkboard

5. Inadequate Schemata Involving Ocular Motilities

To obtain the greatest amount of information in the shortest time and with the least effort, the eyes must be able to scan with speed and control. If eye movements are slow, clumsy or uncoordinated, e.g., if the eyes jump, miss, "stutter" or lose their place on instructional materials, the amount of information obtained will be reduced. Some children seem to have no problems with the organising and performing of ocular motilities for visual inspection of concrete objects, yet demonstrate inadequate performance when placed on symbolic materials. Their inadequate schemata involving ocular motilities become apparent when eye movement control is needed to operate subconsciously while interpretation of abstract symbols occupies consciousness.

Behavioural signs that may indicate inadequate eye movement control include:

- head turns as reads across page
- loses places often during reading
- needs finger or marker to keep place
- displays short attention span in reading or copying
- frequently omits words
- repeatedly omits "small words"
- writes up- or downhill on paper
- rereads or skips lines unknowingly
- orients drawings poorly on page

6. Inadequate Schemata Involving Eye Focus Control

Is it easy for the patient to quickly change focus from near to far, etc. and get clear detail with each change? Can the patient sustain focus at near tasks without fatigue, blur or discomfort?

Clinical experience has shown that spatial awareness, knowledge of the task and voluntary accommodation control all impact on accommodative efficiency. Hoffman[25] reported that accommodative deficiencies and visual/motor perceptual deficiencies are related in children aged 5 years to 7 years, 11 months. He also reported that visual training and lens therapy primarily directed at the accommodative deficiencies improved visual discrimination and attention and visual motor integration and organisation on performance tasks for this age group.

Behavioural signs that may include eye focus control problems include:

- blinks excessively when engaged in visual tasks
- squints or peers to look at fine detail
- rubs eyes after a short period of visual activity
- excessively close or far eye-task

work distance
- fatigues easily, blinks often after working close
- poor ability to sustain attention to fine detail task
- slow adjusting focus far to near, near to far
- complains of blur after reading or writing

7. Inadequate Schemata Involving Binocular Coordination

The human visual system is designed so that the paired eyes and all their reciprocating muscles work as a team. Visual judgments and discriminations of spatial orientation, spatial relationships and depth perception utilize these schemata. More importantly, the immediacy and accuracy of clear, single binocular vision for almost every object and symbol depends on the paired action of the eyes.

Visual attention on, and comprehension of, abstract symbolic materials may be adversely affected by inefficient binocular coordination and eye focus.

Behavioural signs that may indicate eye-teaming control problems include:
- complains of seeing double (diplopia)
- repeats letters within words
- omits letters, numbers or phrases
- misaligns digits in number columns
- squints, closes or covers one eye
- tilts head extremely while working at desk
- consistently shows gross postural deviations at desk activities
- complains of print jumping, running together or moving
- comprehension poorer as reading continued
- photophobia

FATIGUE/STRESS-RELATED VISUAL DYSFUNCTIONS (SCHEMATA BREAKDOWN)

After children have developed the necessary "schemata" for efficient visual function during school tasks, they are still "at risk" if exposed to excessive near seeing demand and prolonged adverse stresses on the visual function.

Indeed, stress-induced visual coordination difficulties can result at any age. Just as our timing and movement management will deteriorate when any of our skills are exposed to excessive demand, fatigue and adverse stress, so will the visual coordination skills deteriorate. Thus, a stress-induced vision problem may result which will limit the person's ability to visually perform with efficiency, comfort and accuracy for any sustained time. Avoiding close visual tasks eliminates symptoms but, otherwise, depending on the degree of deterioration of the visual function, some, or most, of the following symptoms are usually produced:

Symptoms due to fatigue caused by extensive demand on the neuromuscular system:

1. Headaches or aching eyes; pain referred to the muscles of which an excessive effort is demanded. Such symptoms are often associated with excessive or prolonged use of eyes and will disappear or significantly reduce with withdrawal from, or avoidance of, visually demanding tasks.
2. Difficulty of changing focus from near to distance objects or vise versa. Inability to quickly make distant objects clear after sustained close reading without blinking or squinting.
3. Glare discomfort, usually only partly relieved by sunglasses, but characteristically reduced by squinting one eye.
4. Reading comprehension and efficiency drops after a short time on a task.

Symptoms due to failure to maintain constant single binocular vision:

1. Blurring of print (goes funny) or running together of words while reading.
2. Intermittent double vision under conditions of fatigue.
3. One eye turns (without double vision), usually noted by family or friends.

Symptoms due to defective postural sensation:

1. Difficulty in judging distances and positions, especially of moving objects. Timing judgments for hitting and catching small balls are usually difficult.
2. Bumping into objects or misjudgment of position of objects when involved in active visually-directed movement and game play.
3. Feeling of insecurity when quickly dealing with steps, escalators or parking the car.

Programmed Preventive Vision Care

Vision care providers can take active steps to ensure that expectant parents and parents of infants are aware of the active role they can play in guiding and enhancing the emerging visual abilities. Early identification of infants "at risk" will enable the early implementation of appropriate vision care and developmental guidance.

The behavioural approach offers clinical optometry an opportunity to render a unique service.

Thus, programmed preventive vision care is recommended for all children.

a. All infants, other than those who show a need for an earlier examination, should have their first optometric examination at 6 months. This consultation ensures that the structure and physiology of the child's vision system is within normal limits, as indeed it will be in over 90% of cases. Of much more importance, the contact with the parents enables the optometrist to detail the expected visual abilities that will emerge between the age of 6 months and 2 1/2 years.
   Parents can be given written information, such as the preschool Vision Development Checklist recommended by Getman,[26] which gives a general overview of the orderly emergence of visual abilities important to school readiness. Information on environmental enrichment used during intervention programs with children "at risk" can be provided as a measure to ensure the emergence of visual efficiency and to enhance the development of "normal" children.
b. All children should have their second optometric consultation at the age of 2 1/2 years. At this visit the optometrist will make sure that the expected "visual abilities" of a 2 1/2-year-old have indeed emerged. The opportunity then presents for further programming of preventive and enhancement intervention that will be appropriate for the ages of 2 1/2 to 5 years.
   Parents are informed of the visual abilities that will emerge during the next period and when the next examination should occur. The important role that parents can play in ensuring that children achieve "visual readiness for school" can now be stressed.
c. The third examination all children should have would be programmed to occur before the child enters school. At this examination the child is expected

to be able to demonstrate "visual readiness" for school. Children identified as "at risk" because of inadequate visual information acquisition and processing abilities are recommended to appropriate intervention. Consideration may need to be given to delaying the starting at school, particularly if the child is, say, 4 1/2 years old. Just giving some children a little more time to develop by starting them at 5 1/2 can make a significant difference in the child's ability to cope and perhaps their attitude to learning and school.

Decisions on starting or not starting at school are made by the parents on the advice of professionals knowledgeable on the child's abilities: the preschool teacher, the family medical adviser and the developmentally concerned optometrist have much to offer. Parents of children whose abilities are within normal expecteds can be provided again with guidance and enhancement advice applicable for the first year at school.

d. The fourth examination should be scheduled after the child has completed a year at school. The optometrist can now call on the observational skills of the teacher as well as the parents to assess the actual ability of the child in visually coping with these early school demands. Advice on close task posture, pencil grip, study habit development and other aspects of visual hygiene can be provided.

e. The fifth and subsequent examinations are recommended yearly or at clinically judged necessary intervals. Young children with developmental-perceptual deficits and accommodation-convergence inefficiencies provide "preventive care" opportunities.

After the child has developed efficient visual perceptual abilities, he is still "at risk" because of fatigue and adverse stresses that can be placed on the visual processes by the cognitive demand of the "reading to learn" aspects of education.

Thus routine comprehensive optometric evaluations are planned for times when the likely patient benefits from the "preventive approach" will be maximum. Optometrists must plan to provide the best care possible. The resulting "clinical data" on aspects of eye health, eye structure, basic visual physiology, as well as the development of visual information acquisition and processing abilities (visual development and function skills), can then be used for early recognition of children with vision care needs.

CONCLUSION

When parents are aware of the importance of environmental stimulation and sensory motor interactive experiences during their child's development, they are unlikely to "leave things to chance."

An opportunity for preventive care involves educating parents and providing guidance programmes to assist their children in achieving maximum potential in visual information acquisition and processing schemata. Behavioural optometry has a rich resource of information. Solan[22] has meticulously related the emerging visual abilities to age and grade expecteds and compared the profile of the achieving and underachieving populations. As more optometrists gain in-depth information on the behavioural approach, the provision of guidance and developmental lens support to children during the emergence of the schemata of "visual readiness" will become the business of more in optometry.

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