LEARNING PROBLEMS: Theoretical and Practical Considerations of Information Processing

Key Words
ADHD, Ritalin, learning problems, vision training, biofeedback, information processing, accommodation, magnocellular visual system, parvocellular visual system

Approximately 15 million children,1 and approximately 8 million adults2 in the United States have been diagnosed as having Attention Deficit Hyperactivity Disorder (ADHD) with accompanying learning problems. As is well described in the literature, 85% of those diagnosed with ADHD are prescribed Ritalin.3 However, optometrists who treat vision problems on a behavioral/functional basis, raise the possibility that these learning problems can be caused or exacerbated by visual dysfunctions. The basis for this hypothesis was described more than a half-century ago by A.M. Skeffington, O.D., who from 1928 to 1976 was the Director of Education of the Optometric Extension Program (OEP).4

Among the many concepts introduced by Dr. Skeffington were:4 (a) vision is a mode of information processing with a feedback loop; (b) sensory and motor integration is the basis and foundation for learning; and, (c) the importance of central-peripheral visual sub-systems in efficient visual processing. Taken together, these concepts strongly infer that children who have problems processing visual information will not be efficient learners. In fact, it has been my clinical experience that the majority of the children who have been labeled ADHD have an undiagnosed vision problem. The vision problem(s) manifests itself in either a focusing (identification) and/or a binocular vision (centering) deficiency.

These concepts have been stated to reinforce the fact that optometry, in general, and the work of Dr. Skeffington and OEP, specifically, have developed an approach to help remediate individuals with learning problems. It will be helpful to keep these introductory comments in mind while reading the present article.

Presently, only the most important clinical elements will be described. For a more detailed explanation of the critical importance of vision and learning see the work by Kaseno.5

Vision and learning

The model of vision proposed by Livingstone and Hubel6,7 includes a dichotomy of the parvocellular (parvo) and magnocellular (magnio) sub-systems. This dichotomy is present on structural and functional levels at all locations of the visual pathway from the retina to visual cortex; there is a segregation of the parvo and magnio cells.

Basically, the parvo cells exclusively occupy the central visual field, with the remainder of the visual field containing mixed parvo and magnio cells. An appreciation of this dichotomy helps to more fully understand basic myopia and hyperopia and the part vision plays in learning. Basic to this understanding is that in order for efficient visual processing to take place, there must be an effective interaction between the parvo and magnio systems. Table 1 contrasts the characteristics of these systems.8

Previous research has demonstrated that during accommodative relaxation, there is an attenuation of the theta brain wave, amplification of the alpha brain wave, and general muscular relaxation as measured by electromyography.9 These changes are accompanied by the ability to
process many sensory channels simultaneously or, with regard to vision, to optimize the use of both the parvo and magno systems. Thus, accommodation can be the link to foster effective interaction between these two systems in the interest of optimal information processing, which is crucial to reading and learning.

**Determining the type of processing/attentional style of the patient**

It is proposed that when evaluating an individual with a learning problem, the optometrist should determine the patient’s characteristic processing style. The most accurate method is to have the patient read during an electroencephalographic recording: the beta wave has been related to central processing, the theta wave to peripheral processing, and the alpha wave to parallel processing. However, this is not usually feasible in most offices. Consequently, careful observation of the patient can be a reasonable substitute. In the types of processing/attention listed below, parallel processing is the optimal state for effective reading and learning, while peripheral processing is the least effective mode, and is most characteristic of the child with learning and behavioral problems.

**Models of processing/attention**

1. **Parallel Processing** (PP) exists when both central and peripheral vision are processing information simultaneously. A speed reader is an example. He can see the exacting details of each word/letter (CENTRAL) and at the same time be aware of other words/letters on the page (PERIPHERAL). This state of attention also interacts synergistically with memory and other brain functions. Highly effective academic performers can sustain this type of attention appropriately.

2. **Alternating Processing** occurs when the central and peripheral information are processed one at a time; some can perform the alternation very quickly. The average college student will maintain this type of attention and may occasionally utilize PP but is not able to maintain this latter type of processing/attention on a consistent basis.

3. **Central Processing** exists when only detailed information is being processed in a serial fashion for a prolonged time.

| TABLE 1 |
| PARVO VS MAGNO SYSTEMS |
| PARVO | MAGNO |
| Small Cells | Large Cells |
| Sustained | Transient |
| Bright Light | Dim Light |
| Low Contrast | High Contrast |
| Sensitivity | Sensitivity |
| High Spatial | Low Spatial |
| Frequency | Frequency |
| Center | Periphery |
| Identification | Centering |
| Analytical | Viseral |
| Left Brain | Right Brain |
| Cortical | Mid-Brain |
| Cognitive | Non-Cognitive |
| Logical | Emotional |
| Myopia | Hyperopia |
| Derivative | Creative |
| Stereopsis | Gross Depth |
| Color Vision | Perception |
| Beta Wave | Achromotopsia |
| Acuity | Theta Wave |
| Small Receptive Field | Motion |
| Field | Large Receptive Field |
| Focal | Ambient |

This process is typical in many myopic individuals.

4. **Peripheral Processing** occurs when only peripheral information is being processed in a serial fashion. Consequently, the individual is “unfocused” and easily distracted by random thoughts or sensory stimuli not pertinent to the task at hand. This is typical in many individuals who are moderately hyperopic. They are the “C” students who have difficulty staying on the task because their creative-emotional processing is dominant. See Table 1. However, there appears to be another type of peripheral processor. With this type of individual the problem is that there is faulty functioning of this processing channel: the magno channel is not processing the information properly. It is proposed that this is the child with a hard core learning problem. Research has clearly demonstrated that some students diagnosed as having a learning problem have a malfunction of the peripheral (magno) system. Thus, there are two types of Peripheral Processors: the “typical” hyperope, who is primarily a peripheral processor with a well functioning magno system, and the person with a “learning problem,” who is primarily a peripheral processor with a faulty magno system. Usually, this patient has low hyperopia.

**Clinical observations**

Because it is proposed that the accommodative mechanism is the link to optimize parallel processing, it is necessary to investigate it thoroughly. The following tests and considerations should be incorporated into the usual clinical routine.

A. **Latent hyperopia**

It has been noted historically that hyperopia has been correlated with low academic achievement and poor reading ability. Possibly, latent hyperopia is the most significant vision problem for learning-disabled children. This is particularly cogent in the second type of peripheral processor, as previously discussed, who manifests low hyperopia under usual testing conditions. Additionally, because of the frequent presence of an accommodative spasm in latent hyperopia, coupled with the manifest hyperopia itself, there can be an additional stress on these individuals’ visual systems. Consequently, either a cycloplegic or delayed subjective refraction should be performed to uncover any latent hyperopia. Another technique that can be used has been described by Miele. He describes a subjective refractive procedure that utilizes an ascending and descending method of limits. Plus lens blur is reduced until 20/20 is read, then minus lens blur is reduced until 20/20 is read. The span between the plus and minus end points is known as the range of clarity.

B. **Accommodative Function**

Whether one uses the Accommodac® Vision Trainer or flipper lenses, the dynamic functioning of accommodation (i.e., beyond the amplitudes) can be determined. These are the sustainability (i.e., length of time to fatigue) and the equality of each eye in all accommodative functions. It is noted that most children who have trouble learning are deficient in either one or both of these categories.

Using the Accommodac® Vision Trainer, as accommodation reduces, the biofeedback sound increases in frequency. Accordingly, fatigue will be noticed by a decrease in the frequency of the
auditory biofeedback after a short time, 10 seconds or less of training. A difference in accommodative function between the two eyes can be noted by a difference in the frequency range in training each eye. Using flippers, the patient's performance can be compared to normative values.28

As a sympathomimetic drug, Ritalin increases hyperopia and reduces the amplitude of accommodation, thereby exacerbating any frailty of the accommodative system. Appropriate accommodative training is needed for these patients as well as additional techniques discussed.

C. Photophobia

Very often photophobia, a spasm of the iris,19 is associated with accommodative spasm. As is well known, there is a common root for the iris and the ciliary muscles - if there is spasm in one, there tends to be a spasm in the other. During the slit lamp examination of the iris with low light, observe whether there is any hippus. This clinical observation is relevant to complaints of photophobia accompanied by eye strain and ocular fatigue. Typically, a spasm of the iris would be thought to lead to pupillary constriction. However, in the case of the low hyperope with hippus, this is not the usual finding. While it might be expected to note a smaller iris due to spasm, an analogy can made to spastic colon. In the latter case, there is an increase in the frequency and degree of contraction; however, the overall size of the lumen remains the same or mildly reduced.

D. Diplopia

A complete discussion of the dynamics between accommodation and convergence in regard to learning would require a separate paper, and is only mentioned here to stress its importance. Obviously, diplopia has very negative effects on learning and must be corrected.20,21

Diplopia has been noted to be a common problem for children who have been misdiagnosed as having a "learning problem." Quite frequently, the degenerating visual pattern of increasing myopia is associated with an increasing exophoria-exotropia or a deteriorating B syndrome. Concomitant with this increasing exo is diplopia - often unnoticed as it has developed insidiously. Accordingly, children who have had diplopia since an early age may be unaware that diplopia is not the norm. Particular attention should be given to this topic during the case history component of the vision analysis. While the thrust of the present paper is the relationship of accommodation to PP, certainly any successful treatment program must consider the patient's binocular vision pattern. While this may be obvious to some, many practitioners may not pursue the questioning of the child regarding diplopia. A helpful suggestion is to demonstrate diplopia with a trial lens prism. And then inquire again about experiencing diplopia. It is not unusual for children to think that diplopia is a normal concomitant of staring.

How to train PP

Translidal Binocular Interaction Trainer (TBI)

Introduced by Merrill Allen 1967,22 the TBI flashes light to both eyes, with the lids closed, at a rate of 9 Hz. The instrument was originally designed to reduce suppression. This frequency, 9 Hz, is in the Alpha brain wave band. In other words, the TBI puts people into a dominant Alpha brain wave mode that is photically driven. As discussed above, and will be discussed below, the Alpha wave is associated with utilization of PP and may help explain the beneficial effects reported after treatment with the TBI. The lasting effects of photically driven Alpha have not been reported, and most likely will vary from patient to patient. Accordingly, empirical evaluation of each individual patient will be required.

Feedback

The most effective way to enhance PP of visual information is by using biofeedback techniques, as will be discussed later. The key to the training is accessing the information pathways via the accommodative system. As the patient relaxes accommodation, he will have an expansion of his peripheral visual field. Once this can be accomplished on a consistent basis, central stimuli are introduced. Then, in order to perform the required task, he must not relax accommodation fully but must learn to optimize the accommodative relaxation to obtain the largest possible visual field and still maintain clarity of a central visual stimulus. The optimal accommodative relaxation may be related to the reported beneficial effects of low plus lenses by Pierce.23 After the patient has mastered the balancing of central (parvo) and peripheral (magnno) visual information, the distance at which the central stimulus is presented is changed. Finally, accommodative rock is trained while maintaining a wide periphery.

Other physiological measurements have been made while teaching patients these tasks, including electroencephalography (EEG) and electromyography (EMG). When the optimal amount of accommodative relaxation (sympathetic nervous system stimulation) is achieved, the patient goes into a dominant Alpha brain wave state. This is accompanied by a relaxation of the tension in the skeletal muscles. Other research has also shown the relationship between improved learning ability and a dominant Alpha EEG.24,25

Other considerations

Diet

There is evidence that children with learning disabilities are particularly sensitive to sugar.26 Further, because of the appetite suppressing effects of Ritalin, these children eat little or nothing during the day, and maintain their activity by bursts of sugar binges. This causes their blood sugar level to vary with the concomitant swings in mood, etc. Chromium27 is known to help in stabilizing the blood sugar level. The rest involves a sensible, balanced diet.

As both accommodation and blood sugar are controlled by the hypothalamus, a disturbance in one function can have a deleterious effect on the other. Interestingly, Ritalin has another adverse effect in this regard. It has been reported to decrease the amplitude of accommodation and increase hyperopia due to its sympathomimetic property.28

Thus, the optometrist should request the child and/or parent to make a list of all the foods the child likes to eat and make a low sugar menu from the list.

Case history

As recently reported,25 a combination of biofeedback techniques are used to train parallel processing whether the patient is a jet fighter pilot, professional athlete, or a child with a learning problem. The psychological functions that are trained are accommodation, EMG, and EEG. A 10-week protocol is utilized, which in most cases is highly effective in producing parallel processing with much
improved vision function. A case report of such training follows.

The patient was a 17-year-old male with a history of being a slow reader, and not being able to read for more than 10 minutes at a time. He reported that during reading the center fades and the words jump. Vision analysis revealed a small exophoria at near, 7-9 p.d., and manifest subjective refraction of O.D. -1.00 and O.S. -0.75 for 20/20. Ocular health, eye movement status, and visual fields were all within normal limits.

EEG analysis showed that after approximately 20 minutes of reading, the left and right brain recordings of both the Theta and Alpha waves became asynchronous, with the Theta waves becoming larger. (see Figures 1 and 2.)

In other words, there was a clear correlation between loss of reading comprehension and a dramatic change in the EEG. In addition to accommodative and EMG biofeedback training, he received training to increase the Alpha brain wave activity during reading. EMG training consisted of teaching the patient how to relax the frontalis and masseter muscles. General muscular relaxation is related to having an enhanced Alpha brain wave. His baseline of being able to maintain Alpha during reading was 1% of the time, and after 14 training sessions achieved 100%. Five years later, his mother sent the following letter: 29

"Regarding the visual training program of Dr. Trachten, I attribute his training as a significant contributor toward the success of my son, _____’s, academic performance. _____ graduated from College with a major of Biology and Chemistry. Following the results of his Biology GRE examination, he was accepted at the universities of _______, _______ and in Bio-Medical research. In addition, all of these institutions offered ____ full free tuition as well as $15,500 a year. _____ chose the University of _______ and is doing quite well."

"As a Community Psychologist, working in a variety of settings and with diverse populations, I recognize a plethora of benefits that could be realized through the visual training program offered by Dr. Trachten"  

Improvement in accommodative function, EEG pattern, and EMG levels were accomplished as a result of the training program. This was reflected in his performance as he was transformed from a non-reader to a highly successful graduate student.

Conclusion

Theoretical and practical consideration have been presented relating the role of accommodation in information processing. More specifically, it is noted that many children who have learning problems have difficulty with their magneto system function. The diagnosis of faulty accommodation accompanied by low hyperopia are strong clues that there is an imbalance between the parvo and magneto systems. The practical applications of these theoretical considerations are demonstrated in a case history, where biofeedback was employed to increase accommodation function and the Alpha component of the EEG, leading to a marked improvement in information processing.

Many of the topics in this paper were not by Dr. Skeffington over a half-century ago. As behavioral optometrists we have had, and still have, the unique opportunity and responsibility to be able to help millions of people labeled ADHD, who have been misdiagnosed, misunderstood, and subjected to frequently unnecessary powerful drugs.

Footnote

a. The simplest technique for disclosing the extra plus which the patient will accept for steady wear is the technique described by the author (1945) and also Baxter (1946), which consists of a simple combination of fogging and cycloplegia. b. At the conclusion of the phoropteric routine, the last test usually taken at rear is the test of negative relative accommodation during which plus is added until nearpoint letters are blurred. c. Leaving these lenses before the eyes, the nearpoint chart is removed and the patient's at-
tention is directed to the best line of letters seen during the subjective test, which are now badly blurred. d. The plus lens before the eye is reduced until these letters are again visible. (It is best to check this visibility point by the duochrome or other check methods used in determining the sphere during the subjective test to be assured of the same degree of acuity.) Frequently, it will be found that the residue of this test exceeds the plus value found during the previous routine subjective.” Borish, I.M. (ed.) Clinical Refraction. Third Edition, New York: Professional Press, 1970, pp 788-789

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