Dyslexia and other reading problems: An optometric perspective

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Abstract
As vision care specialists, optometrists are often consulted when a child shows signs of reading difficulties which cannot be improved with standard remedial reading techniques. In many instances the child may have already been labeled as having "dyslexia". Since this term is often abused, the optometrist should explore the problem and formulate his/her own diagnosis. This paper will give optometrists a working knowledge of how to help these children and how other professionals deal with reading difficulties. The role of the optometrist as a possible coordinator for this difficult diagnostic process which often involves many other professionals will be also be described.

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Thesis

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DYSLEXIA AND OTHER READING PROBLEMS: AN OPTOMETRIC PERSPECTIVE

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MAY 1986
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ABSTRACT

As vision care specialists, optometrists are often consulted when a child shows signs of reading difficulties which cannot be improved with standard remedial reading techniques. In many instances the child may have already been labeled as having "dyslexia". Since this term is often abused, the optometrist should explore the problem and formulate his/her own diagnosis. This paper will give optometrists a working knowledge of how to help these children and how other professionals deal with reading difficulties. The role of the optometrist as a possible coordinator for this difficult diagnostic process which often involves many other professionals will be also be described.
INTRODUCTION

Although leading authorities in the field of learning disabilities seem to classify dyslexia as an entity separate from reading problems, the terms are still used interchangeably. Thus, it is necessary to be familiar with the history of reading problems and definitions that have evolved as a result of continued research and controversy. In 1896, Morgan published a classic paper describing a 14-year old boy of normal intelligence who was severely disabled in reading and writing. He attributed this problem to a defect in the left angular gyrus, basing his theory on the evidence found in adults who had suffered injury to this area of the brain. He named the condition "alexia" or word-blindness.

Hinshelwood later published a series of papers (1900, 1902, 1909) describing more cases of this type. Nettleship, who was the first researcher to describe the problem in a woman (1901), also brought to attention the preponderance of males afflicted by this condition. A stream of researchers quickly followed with their own case reports and theories but most seem to agree on a neurological cause leading to a visual - perceptual deficiency. Several case studies even suggested a hereditary nature.

Although the early cases were exclusive to the English-speaking countries, researchers quickly discovered that the problem was universal as other countries published their own cases. The theory of reading problems caused by language structure vanished as a result. In the 1920s, Orton introduced a new neurological perspective by emphasizing the phenomenon of letter reversals in children with reading problems. He termed it strephosymbolia or "twisted symbols" and attributed this problem to a lack of laterality or preference for one side of the body leading to the inability to differentiate right from left.

With the advent of modern technology, new methods become available for the study of brain behavior correlates. These techniques (EEG, CAT scans, regional cerebral blood flow mapping) allow scientists to derive knowledge about the reading process and its associated problems. It is now believed that reading ability results from integration of the primary sensory zones of the brain (auditory, visual, tactual) which process incoming stimuli separately and then transmit these signals to the angular gyrus via short association fibers. Duffy et al found differences between the dyslexic and normal groups when recording the activation and at rest EEG activities throughout different areas of the brain. Using topographic mapping of these aberrant activities and a statistically based classification technique this group of researchers were able to identify ninety percent of the dyslexics. However, not all professionals who deal with reading
problems agree on a neurological cause of dyslexia. Each would propose a different definition which emphasizes the aspect he/she considers to be the chief cause.

Despite these disagreements, the term dyslexia, which literally means "impaired word" (dys-impaired; lexis - word, speech) has gained popularity. Unfortunately, many authors tend to ignore the implications of the term dyslexia and use it indiscriminately to label any child with reading problems regardless of etiology.

In 1968, the World Federation of Neurology issued the following definition of dyslexia in order to reduce the confusion caused by describing a disorder according to its symptoms:

"A disorder manifested by difficulty in learning to read despite conventional instruction, adequate intelligence and sociocultural opportunity. It is dependent upon fundamental cognitive disabilities which are of constitutional origin."\(^{33}\)

As the government became more involved in the funding of special remedial programs for dyslexic children, a specific definition was necessary for the classification and allocation of funds. The U.S. Office of Education (1970) published this definition of "specific learning disability" which also includes dyslexia. It defines children with "specific learning disability" as having

"...a disorder in one or more of the psychological processes involved in understanding or using language, spoken or written, which disorder may manifest itself in imperfect ability to listen, think, speak, read, write, spell or do mathematical calculations. Such disorders include such conditions as perceptual handicaps, brain injury, minimal brain dysfunction, dyslexia and developmental aphasia. Such a term does not include children who have learning problems which are primarily the result of visual, hearing or motor handicaps, of mental retardation or emotional disturbances, or of environmental disadvantages."

This definition is more specific than that given by the World Federation of Neurology but they both imply neurological dysfunction as the cause of dyslexia. Although the medical profession has adopted this view of dyslexia, much controversy and resistance stills exist among educators and optometrists who are reluctant to apply the label of dyslexia with its neurological implications to children with severe reading disabilities.\(^{25,33}\) This disparity of opinions among the specialists creates an obstacle for the diagnosis and remediation of children with reading/learning problems.

In dealing with reading difficulties, the optometrist must explore beyond the label in order to get to the true problem. Using performance test results from normal children as well as those with reading problems, Weisberg found that the diagnoses given by a panel of reading specialists for the same test results vary widely. The correlation of agreement between two specialists is only 0.07. She also found that the nature of the training of reading specialists fails to provide them with
a solid diagnostic framework such that when the same results are re-introduced to the same specialist, a totally different diagnosis may be given ($r=0.17$). 

Considering how inconsistent the diagnosis of reading problems can be, the optometrist should maintain an open mind when dealing with a child who have been labeled "dyslexic". We believe that "true dyslexia" exists but is a rare syndrome. For most children with reading problems there is often an underlying identifiable cause. Pavlidis found that 70% of the "dyslexics" that had been diagnosed by other professionals did not meet these specific criteria he had set up to define dyslexia:

1. Performance or verbal IQ at least of an average level (90 or above for WISC).
2. At least 1.5 years retarded in reading if below 10 years and at least 2 years retarded in reading if age > 10 years (reading retardation assessed relative to chronological age).
3. Normal or corrected vision (children with nystagmus were excluded).
5. Subjects came from an upper-middle socio-economic background (with the language spoken at home being English).
6. Adequate educational opportunities, quantified according to the following criteria: a. they did not have more than two school changes (excluding normal transfer from nursery to primary to secondary school); b. they were not absent more than 2 weeks per term or did not have more than the average absenteeism occurring in the educational area from which the dyslexics and controls were drawn.
7. They did not have any overt physical handicaps that could account for their reading problems, such as brain injury and/or tumor.
8. They did not have any overt emotional problems before beginning reading. 

These criteria prove to be the most satisfactory working definition of primary "dyslexia" for clinical use. They can serve as guidelines in dealing with children with reading difficulties.

OVERVIEW OF THE VARIOUS PROFESSIONAL APPROACHES

As was stated, "reading difficulties" is an elusive term which holds a different meaning for each profession, depending on what is considered to be the chief cause. This paper is aimed at giving the reader an insight into the way different professions approach reading difficulties. The role of the optometrist will be discussed first since he/she is often the primary entry into the health care system.
The optometric approach

I. **Optometric Approach**

**Theory**

Optometry has no standard method of remediation for children with reading difficulties. The problem stems from the expanding scope of optometry and the diverse modes of practice. Not all believe in the usefulness of vision therapy and among those who advocate this aspect of optometry, there are still varying views as to what this entails. Depending on the individual practitioner, vision therapy can range from simple eye movement exercises to perceptual-motor training.

The optometrist's role should be to identify subtle visual anomalies which may contribute to the reading problem. Studies have shown the importance of accommodation, fusional amplitudes and binocularity on reading efficiency.

Before we discuss the different training techniques we would like give an overview of perceptual-motor development theories. Skeffington believes that vision is the result of the integration of four basic systems that operate simultaneously. The anti-gravity process provides information about the whole person in space through inputs to the eyes, ears and muscles. The centering system gives feedback of where things are in relation to self whereas the identification system integrates sensory inputs. The speech-auditory process allows verbalization and/or visualization of these perceptions.

Getman's visuomotor model stresses the dependence of each successive stage of development upon a solid earlier level. The framework will be weakened if a new stage is started before the child has mastered the previous one thus creating stress.

According to Kephart, a child must have a normal perceptual-motor development to establish a solid, reliable concept of the world. This theory also believes in a fixed order of motor development for normal children. The above three theories provide the foundation for most training techniques employed in the treatment of children with reading difficulty.

As discussed earlier, the scope of vision therapy is broad and rather hard to define. The role of eye movement exercises is still a much disputed issue. Many researchers have noted the presence of abnormal eye movements among poor readers and this has led to the following hypotheses:

1. the erratic eye movements cause reading problems;
2. the erratic eye movements are caused by reading problems which result from a central nervous system deficit.
Many optometrists adopt the first hypothesis and base their training on it. They believe that efficient eye movements will improve reading ability. Others feel that this theory only applies to some cases and not all children with reading difficulty, i.e. those with dyslexia.

Several studies using the EyeTrac to record eye movements during a non-cognitive task as well as while reading seem to support the second hypothesis. Even those who subscribe to this theory are divided on how these children should be managed. The two basic philosophies disagree on the role optometry should play in the remediation of these children. However, they both believe that the erratic eye movements are the result of perceptual difficulties.

The developmental optometrist believes that normal perception is the result of a proper linkage of the different sensory modalities, i.e. visual, auditory and motor system. Therapy is devised to teach the patient how to relate these sensory modalities. As vision specialists, optometrists can play an important role in the remediation of children with reading difficulties. Evidence exists as to the efficacy of optometric vision therapy in treating children with reading difficulties in appropriate cases. Before therapy can begin, the optometrist needs a framework to rule out or identify other possible causes and seek proper consultation when necessary.

**Differential Diagnosis**

When faced with a child who has been labeled as "dyslexic", the optometrist needs a systematic approach to avoid being overwhelmed by the confusing controversial issues. To aid the clinician in screening children with reading difficulties we have developed a flow chart which should help rule out or identify non-visual causes. The tests listed are selected because they are simple to administer and yield results which correlate well with standardized tests.

The initial evaluation step for any child with reading problems should include a detailed case history covering health problems including the pregnancy and birth process. This can also uncover any behavioral or emotional problems the child may have such as hyperactivity, anti-social behavior, etc.

To eliminate mental deficiency as a possible cause of reading difficulty, the Peabody Picture Vocabulary Test can provide a quick assessment of the child's intelligence.

Children who have reading problems caused by a central deficit often show subtle motor control abnormalities. These can only be detected by a special battery of tests aimed at the higher levels of fine and gross motor activities.

Auditory problems can hinder the reading process and yet hearing losses are easily overlooked at standard school screenings. Thus, we feel that the clinician needs to rule out this
problem with a quick screening test. As in vision, the ability to integrate incoming stimuli with the other senses is critical. The tests used most frequently to assess this ability include the Test of Auditory Analysis Skills (TAAS) and the Auditory Visual Integration Test (AVIT) Birch Belmont.

Assessment of the visual system should include not only the standard optometric battery but also the perceptual and developmental tests to evaluate the child's ability to process visual information.

Based on the data gathered, the optometrist can then make appropriate consultation or possible referral for further work-up. (See Appendix A)

Management

Optometric training techniques for reading difficulties can be classified into these three general categories; visual perception, visual-motor integration and auditory-motor integration.

Visual perception therapy includes visual discrimination, visual memory, visual sequencing, visual closure and figure-ground techniques. Eye-hand coordination exercises, copy forms and balance techniques belong to the visual-motor integration category. Auditory-motor integration techniques teach the child to take auditory stimuli and put them into action. The table below is a list of the above categories along with representative techniques.

<table>
<thead>
<tr>
<th>Category</th>
<th>Training Techniques</th>
</tr>
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<tbody>
<tr>
<td><strong>Vision perception</strong></td>
<td></td>
</tr>
<tr>
<td>- visual discrimination</td>
<td>Same or different game (PUCO Battery)</td>
</tr>
<tr>
<td>- visual memory</td>
<td>Tachistoscope</td>
</tr>
<tr>
<td>- visual sequence</td>
<td>Visual Sequencing Game (PUCO Battery)</td>
</tr>
<tr>
<td>- visual closure</td>
<td>Dot-to-dot games</td>
</tr>
<tr>
<td>- figure-ground</td>
<td>Hidden picture book</td>
</tr>
<tr>
<td><strong>Visual-motor integration</strong></td>
<td></td>
</tr>
<tr>
<td>- eye-hand coordination</td>
<td>Ball-and-stick game</td>
</tr>
<tr>
<td>- copy form</td>
<td>VMI (Beery)</td>
</tr>
<tr>
<td>- balance techniques</td>
<td>Balance board exercises</td>
</tr>
<tr>
<td><strong>Auditory-motor integration</strong></td>
<td></td>
</tr>
<tr>
<td>- auditory sequencing</td>
<td>AVIT (Birch-Belmont)</td>
</tr>
<tr>
<td>- auditory memory</td>
<td>&quot;Simon says&quot; game</td>
</tr>
</tbody>
</table>
This by no means is a complete listing of all the vision therapy techniques available. There are many philosophies as to when vision therapy should be implemented. Some adopt the attitude that vision therapy, unlike many medical therapies, cannot hurt, and should be tried when all else fails or even before any other therapies are attempted. We do not hold that belief because it undermines optometry's credibility. We also feel that this approach can actually hurt the patient and take precious time that could be better spent in tutoring and other remedial activities.

The visual skills which have been shown to improve reading performance include accommodation, fusional ranges, binocularity, eye movements and perceptual abilities. These can be easily enhanced with standard optometric therapy.

We are in favor of vision therapy in cases when these skills are below expected levels and a hinderance to reading. In acquiring a more efficient visual system, the child needs less energy for the information gathering process. This would facilitate information processing resulting in improved comprehension.

II. Medical Approach

The pediatrician plays an important role in assessing the child's general health and ruling out common childhood disorders which can affect learning ability. In school-aged children, the most common conditions which can have detrimental effects on learning abilities are sensory deficits (auditory, visual) and hyperactivity.

Auditory Problems

Children are frequently plagued by recurrent middle ear infections which in some cases can lead to gradual hearing loss. Hartford et al. reported that approximately 70% of all children have had otitis media by the age of seven. However, only 15% of the children develop hearing loss as a result of recurrent infections. Several studies have specifically linked reading problems and recurrent middle ear infections. In a study comparing students with learning problems and normal students, Hutton reported a higher incidence of middle ear pathology (25% vs 12.8% in normal group) showing the importance of good hearing to learning abilities. A careful otoscopic examination combined with detailed hearing tests help the physician evaluate the extent and nature of any hearing deficiency. Two basic methods of testing are used in audiology: pure tone testing and speech audiometry.
The human ear responds to frequencies from 20 to 20,000 Hz with its maximum sensitivity in the 1,000 - 1,500 Hz range. However, only the frequencies between 300 to 3,000 Hz are critical for speech perception. In pure tone testing, the frequencies are presented one at a time and fall in the range of 125 to 8,000 Hz. Although people are rarely exposed to pure tones in the environment, this testing method provides a good indicator of hearing ability as well as information about the site of lesion when a hearing defect is detected.

Speech audiometry uses standard spoken words to quantify hearing loss resulting in communication difficulty. These words, also called spondees, are bisyllabic and delivered with approximately equal stress on both syllables. Both the spondee threshold (ST) and pure tone average (PTA) should agree.

Hearing losses can be grouped into three general categories: conductive, sensory and neural. Depending on the range of hearing loss, the child can show different patterns of misspelling when certain vowels are missed altogether. Proper diagnosis and treatment, whether with an appropriate hearing aid or drainage and elimination of a possible ear infection, will allow the child to benefit from remedial instructions.

Hyperactivity
Hyperactivity has often been linked to learning problems in school-aged children. However, the clinician faces a difficult task when trying to distinguish an overactive normal child from a true case of hyperactivity which is a complex syndrome with multiple causes from frank brain damage to temperament problems. Minimal brain dysfunction, learning disability, and hyperactive child syndrome are sometimes used interchangeably in the literature leading to considerable confusion. This mixing of terminology stems from early works which show hyperactivity in children with signs of brain damage.

In evaluating the hyperactive child, the pediatrician needs a detailed case history, a physical examination complete with some routine laboratory tests to rule out a number of physiological causes such as hyperthyroidism, food allergies, lead poisoning, etc. Sometimes, more specialized tests such as EEG may be necessary to detect more subtle disorders. The need of a complete medical examination in managing hyperactive children is still questioned. However, since hyperactivity is a symptom and not a disease, steps should be taken to rule out any underlying medical conditions which can be treated.

A neurological examination may reveal any central nervous system degeneration which can cause hyperactivity. The child with major neurological problems can be easily diagnosed by a neurologist with the use of specialized tests. Minimal brain dysfunction, on the other hand, only shows subtle changes called "soft signs" which may be overlooked in a standard neurological
exam. The types of impaired functions seen in hyperactivity include poor fine motor coordination, poor perceptual abilities which cause learning problems. Touwen designed a detailed test sequence aimed at detecting minor neurological deficits in children with learning problems.

The popular medical management of hyperactive children is through the use of stimulant medications which exert a paradoxical calming effect. A questionnaire survey of 700 physicians in the Chicago area revealed that approximately 2% of the school-ages children are under medication. Two central nervous system stimulants that have been used most extensively are dextroamphetamine (Dexedrine) and methylphenidate (Ritalin). The latter drug is preferred since its introduction in the late 1950s due to its greater efficacy and fewer side effects. Other psychoactive substances also used include caffeine and magnesium pemoline (Cylert), imipramine which is an antidepressant and phenothiazine, a tranquilizer. However, the amphetamines and methylphenidate still seem to be widely used.

Studies of the effects of psychoactive drugs have shown almost immediate and dramatic improvement in fine motor skills performance and classroom behavior. Many children taking these drugs have longer attention spans resulting in better academic performance as reflected by higher scores on achievement tests.

In dealing with any systemic drug, we have to consider the side effects to determine if the desired effects outweigh the negative ones. The most frequent short-term side effects are anorexia and insomnia which usually occur more with the amphetamines. Long-term side effects may include increased heart rate and growth suppression. However, the growth rate increases to a higher level than normal when the drug is discontinued.

Since the medications for hyperactive children are palliative rather than curative, how then does the clinician decide if the child is "cured"? The general feeling seems to be that hyperactive children grow up to be hyperactive adults who are more likely to channel their energy into more constructive tasks. Brown et al., found that hyperactive children do not reach normal attention levels with maturation; hyperactive adolescents have diminished activity levels but they continue to be impulsive, emotionally immature and have impaired attention. The child, however, needs to be slowed down enough for any learning to occur.

III. Psychologist and Educator Approach

Diagnosis

Due to their close daily association, the school psychologist and the educator are often the first professionals to label a child with reading difficulties.
Essential to the diagnostic process, the psychologist and the educator must determine several things. First, there must be an evaluation of the child's present achievement level to discover the areas of failure. Second, an analysis of the child's information processing must be performed to discover why the child is not learning. Finally, the data collected must be organized and interpreted to formulate a diagnostic hypothesis.

Obtaining data for the diagnosis involves a detailed case history, clinical observations, informal testing and formal standardized testing. In actuality, these four areas have much overlap. Through the information gathered in the case history and clinical observations, the specialists is directed towards tests which are appropriate in arriving at final diagnosis of the child.

The case history and clinical observations of the psychologist should involve the same basic questions and observations made by the optometrist. Areas that are of importance to evaluate besides those included in a regular case history include observations of the child in a variety of behavioral settings and an assessment of the level of emotional maturity of the child.

Informal non-standardized testing may include tests of reading, arithmetic and word recognition. These tests should be quick and easily administrated, yet give the specialist an idea of the child's areas of weakness.

Formal standardized tests used by both the psychologist and the educator to assess broad spectrum aspects of intelligence include the Wechsler Intelligence Scale for Children (WISC), the revised version WISC-R, and the Stanford-Binet Intelligence Scale. The Stanford-Binet yields a single score including mental age and intelligence, while the WISC and WISC-R provide a verbal IQ, a performance IQ and a full-scale score.

In addition to general intelligence tests, there are tests to examine specific mental processing, perceptual and/or cognitive factors. One such test, the Illinois Test of Psycholinguistic Abilities (ITPA), is used to identify specific areas of learning difficulty in language.

Other tests educators and psychologists use in assessing mental processing include the Bender Visual-Motor Gestalt Test for Children and the Marianne Frostig Developmental Test of Visual Perception. A test that is used as an estimate of visual perception and intelligence is the Goodenough-Harris Drawing Test. Auditory perception tests may include the Wepman Test of Auditory Discrimination and the Roswell-Chall Auditory Blending Test.

Psychologists and educators also want to evaluate the child's reading ability. Tests like the Gates-MacGinhte Reading Tests, the Stanford Achievement Test, and the Metropolitan Achievement Tests: Reading, give a general score of silent reading and indicate the level at which the child reads.

Diagnostic reading tests differ from the general reading tests in that they give information on how the child reads rather than the level. Tests of this type include: Gates-McKilrop Reading

Tests used to measure academic performance in subjects such as reading, arithmetic, spelling and grammar include: Wide Range Achievement Test (WRAT), SRA Achievement Test and the Metropolitan Achievement Tests.

Management

Once all of the data have been gathered, interpreted and analysed, the psychologist or educator is faced with bringing all of the information together to formulate an educational plan which should be best suited for the child's strengths and weaknesses. The optometrist can also work closely with these professionals by coordinating the results from the optometric and medical work-ups. This can help the educator better understand the full scope of the child's problems.

Many experts in the field of education feel that the current educational system is very piecemeal and does not provide a coherent curriculum for children to learn by. Since the human mind can only develop ideas one process at a time, the curriculum must not require children to do more. As we know, a reading difficulty does not "develop", but rather it results from the child's inability to read given reasonable opportunity. But, these experts propose, what if the traditional classroom setting is not "reasonable opportunity" for some children. As Eisenberg (1978) wrote: no one would label as dyslexic a child who never has been taught. Possibly reading difficulties come about as a shortcoming of the educational process rather than a difficulty from within. Others in the profession argue that to blame an educational curriculum for a child's difficulties is to overlook the nature of the reading difficulty.

Because of the vast differences in opinion as to "the method" to educate children with reading difficulties, dozens of teaching methods are in practice. However, these methods generally fall into one of two groups; one placing emphasis on the rules of coding, the other the meaning of the text. Items of the first category include alphabetical methods, phonic methods and those methods which use diacritical markings and/or color. The second category places emphasis on the whole-words, sentence methods and those based on spoken language experience. Critics contend that methods that emphasize reading with and for meaning from the beginning do not give children a chance to learn code, and children cannot learn to read unknown printed words unless they master the code. This is especially true of children with reading difficulties.

There are several training programs published for educators designed to help the child with reading difficulties. Pioneers in this field, Anna Gillingham and Bessie Stillman devised the first such program, from which other programs with the same basic premise have since developed. Gillingham and Stillman's program is aimed at decoding and encoding skills which arise on
associations between sounds and symbols, and upon a thorough understanding of the structure of written language. Phonic drills and constant revision are built into the program.  

Teaching children with reading difficulties is not an easy job. However, by sticking to one of the programs devised by forerunners of the field, the novice teacher is provided with a structured systematic approach. This is not to say that every effort should not be made to adapt materials and methods to the needs of individual students. However, a key to the enhancement of instruction lies in training educators to have a coherent instructional program which they share with their students.

Various educational service systems are in vogue today for children with reading difficulties. One such system is mainstreaming, an integrating of children with reading difficulties as well as children with other handicaps, into the regular school classroom. In such a situation the classroom teacher is responsible for teaching all of the children regardless of their academic level.

Another form used is the itinerant program in which children with reading difficulties are singled out for special help when the itinerant reading teacher is at the public school to provide this service. These teachers generally travel to many schools within a district and see children with reading difficulties at each school.

A stronger approach used in the public school is a contained special classroom. The ultimate goal of these classes is to organize the child for eventual return to a traditional classroom setting.

The final system we will mention is the private, special day school (e.g. Mt. Olive in Portland, OR or the Miriam School in Webster Grove, MO) which is a specially designed school facility for children with reading difficulties. In this system, the child spends the school day in this special facility and is given intensified individualized attention. Some children with severe difficulties may attend this school full day, while others with less severe reading difficulties spend half of the day here and return to the public school for the balance of the day.

By the time a child is labeled as dyslexic, they have fallen behind their peers and suffer not only educationally, but emotionally. Because of this, the need for the educator and school psychologist goes on, far beyond the initial diagnosis and treatment.

CONCLUSION

Our research has led us to three major conclusions. Firstly, a multidisciplinary approach is ideal but not feasible except in large metropolitan areas. In most instances, the child is shuffled between the offices of various professionals who do not communicate amongst themselves. With the proper background, the optometrist may be best suited to serve as the coordinator of these activities. This may provide the most efficient approach to the child's problem.
Secondly, prevention by early identification of high risk children is of major importance. Prevention would decrease the need for remediation which is often costly. Furthermore, it will save these children from experiencing failure which can leave emotional scars.

Lastly, optometry, through the use of vision therapy can play an important role in the remediation of reading difficulties. However, we will need to arrive at a consensus of the boundaries of vision therapy.
## APPENDIX A

### Tests for differential diagnosis

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<th>Case History</th>
<th>Consult for further work-up</th>
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<tr>
<td>General health</td>
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<tr>
<td>Hyperactivity (see Appendix B)</td>
<td>Psychologist</td>
</tr>
<tr>
<td>Psychological/Social factors</td>
<td>Educator</td>
</tr>
</tbody>
</table>

### IQ Testing

| Peabody Picture Vocabulary Test (PPVT)¹ | Psychologist |

### Motor Control (see Appendix C)

1. Fine motor
   - Fingertip-nose test
   - Fingertip touching test
   - Finger opposition test
   - Circle test
2. Gross motor
   - Walking on tip-toe
   - Walking on heels
   - Standing on one leg
   - Hopping on one leg

### Auditory system

| Audiological screening list (see Appendix D) | Pediatrician |
| Test of Auditory Analysis Skills (TAAS)² | Educator |
| Auditory Visual Integration Test (AVIT) Birch-Belmont³ | |

### Visual system

| Acuity/Refractive error | Optometrist |
| Convergence | |
| Accommodation | |
| Eye movements | Pediatric neurologist |
| Motor-Free Visual Perception Test (MVPT)⁴ | Educator |
| Developmental Test of Visual-Motor Integration (Beery)⁵ | Developmental optometrist |
| Visual-Aural Digit Span⁶ | |
| Jordan Left-Right Reversal Test⁷ | |
| Six Figure SplitForm Board⁸ | |
| Test of Visual Analysis Skills (TVAS)⁹ | |
| Purdue Perceptual-Motor Survey¹⁰ | |
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### APPENDIX B

Percent positive scores in the patient and control groups for symptoms scored positive by one-third or more of the patients

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Patients</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overactive</td>
<td>100</td>
<td>33</td>
</tr>
<tr>
<td>Can't sit still</td>
<td>81</td>
<td>8</td>
</tr>
<tr>
<td>Restless in MD's waiting room</td>
<td>38</td>
<td>3</td>
</tr>
<tr>
<td>Talks too much</td>
<td>68</td>
<td>20</td>
</tr>
<tr>
<td>Wears out toys, furniture, etc.</td>
<td>68</td>
<td>8</td>
</tr>
<tr>
<td>Fidgets</td>
<td>84</td>
<td>30</td>
</tr>
<tr>
<td>Gets into things</td>
<td>54</td>
<td>11</td>
</tr>
<tr>
<td>Unpredictable</td>
<td>59</td>
<td>3</td>
</tr>
<tr>
<td>Leaves class without permission</td>
<td>35</td>
<td>0</td>
</tr>
<tr>
<td>Unpredictable show of affection</td>
<td>38</td>
<td>3</td>
</tr>
<tr>
<td>Constant demand for candy, etc.</td>
<td>41</td>
<td>6</td>
</tr>
<tr>
<td>Can't tolerate delay</td>
<td>46</td>
<td>8</td>
</tr>
<tr>
<td>Can't accept correction</td>
<td>35</td>
<td>0</td>
</tr>
<tr>
<td>Temper tantrums</td>
<td>51</td>
<td>0</td>
</tr>
<tr>
<td>Irritable</td>
<td>49</td>
<td>3</td>
</tr>
<tr>
<td>Fights</td>
<td>59</td>
<td>3</td>
</tr>
<tr>
<td>Teases</td>
<td>59</td>
<td>22</td>
</tr>
<tr>
<td>Destructive</td>
<td>41</td>
<td>0</td>
</tr>
<tr>
<td>Unresponsive to discipline</td>
<td>57</td>
<td>0</td>
</tr>
<tr>
<td>Defiant</td>
<td>49</td>
<td>0</td>
</tr>
<tr>
<td>Doesn't complete project</td>
<td>84</td>
<td>0</td>
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<tr>
<td>Doesn't stay with games</td>
<td>78</td>
<td>3</td>
</tr>
<tr>
<td>Doesn't listen to whole story</td>
<td>49</td>
<td>0</td>
</tr>
<tr>
<td>Moves from one activity to another in class</td>
<td>46</td>
<td>6</td>
</tr>
<tr>
<td>Doesn't follow directions</td>
<td>62</td>
<td>3</td>
</tr>
<tr>
<td>Hard to get to bed</td>
<td>49</td>
<td>3</td>
</tr>
<tr>
<td>Enuresis</td>
<td>43</td>
<td>28</td>
</tr>
<tr>
<td>Lies</td>
<td>43</td>
<td>3</td>
</tr>
<tr>
<td>Accident prone</td>
<td>43</td>
<td>11</td>
</tr>
<tr>
<td>Reckless</td>
<td>49</td>
<td>3</td>
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<tr>
<td>Unpopular with peers</td>
<td>46</td>
<td>0</td>
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</tbody>
</table>

APPENDIX C

FINGERTIP-TOUCHING TEST

Age

This test is suitable for all children between the ages of three and 12 years, but it can only be performed by children of six years and over with the eyes closed.

Procedure

The examiner stands in front of the child and points an index finger at him, keeping his elbow flexed. The child is asked to put the tip of his index finger on the tip of the examiner’s finger, the distance between them being such that the child has to flex his elbow to accomplish this. The test is carried out three times with each hand, first with eyes open and then with eyes closed. The examiner must take care not to change the position of his finger.

Recording

The test is scored for quality, i.e. intention tremor during movement and when the finger is placed, and adequacy, i.e. success in placing the fingertip on the examiner’s finger. Separate recordings are made when the eyes are open and when the eyes are closed.

Tremor during movement:  
0 = no tremor present.  
1 = slight tremor.  
2 = marked tremor

Tremor of the placed finger:  
0 = no tremor present.  
1 = slight tremor.  
2 = marked tremor.

Placing the finger:  
0 = the child places his finger correctly on the examiner’s fingertip each time.  
1 = the child misses once or twice.  
2 = the child misses each time.

Consistent deviations and misplacements to one side are also described.

Significance

The optimal response (score 0) consists of the child placing his finger smoothly and adequately on the examiner’s fingertip. When done with the eyes open, visual guiding plays a preponderant role, and, as such, the test gives some general information about hand-eye co-ordination. When carried out with the eyes closed, cerebellar and proprioceptive systems are preponderant for the performance. Generally speaking, the presence of a tremor denotes cerebellar dysfunction, whilst deviations of placing reflect sensory proprioceptive dysfunction. Deviations which occur persistently to one side may be cerebellar or vestibular in origin; in young children (e.g. five- or six-year-olds), a score of 2 for placing the finger with no constant deviation toward one side may also reflect a maturational delay of cerebellar functions. Non-cerebellar hypotonia is of course excluded. A score of 1 in placing the finger with eyes closed is normal (albeit non-optimal) in children up to seven or eight years of age. What has been said about elbow support against the body in the section on the Finger-nose Test also applies for this test.
A regular, rather fine tremor - commonly called 'essential' or 'psychogenic' tremor - may be observed, especially while the child's finger rests on the examiner's finger. The term 'psychogenic' emphasizes the need for the child to be in the proper behavioural state, as any tension or nervousness may provoke this type of tremor. It is usually of no clinical significance. Consistent unilateral deviations to one side may reflect a unilateral cerebellar dysfunction, and if there are consistent deviations to one side in both hands, vestibular dysfunction may be involved as well.

**FINGER OPPOSITION TEST**

**Age**

This test is applicable to most children of six years and older. Some agile five-year olds are also able to perform it.

**Procedure**

The examiner demonstrates to the child how to place the fingers of one hand (starting with the index finger) consecutively on the thumb of the same hand in the following sequence: 2, 3, 4, 5, 4, 3, 2, 3, 4, 5, etc. The child is asked to imitate these movements, completing five sequences to and fro. Each hand is tested in turn. The test should be carried out at a rate of approximately three to four seconds for one complete sequence.

**Recording**

This test is scored on three aspects: the smoothness of movement, governed by hesitations in correcting mistakes and associated movements in the other fingers of the same hand; smoothness of transition from one finger to the next, especially at the turning-points involving the index and the little fingers; and mirror movements, i.e. associated movements in the opposite hand.

A distinction must be made between a poor performance in the general 'smoothness of movement' (which may include hesitation in correcting mistakes) and a poor performance in the smoothness of the finger-to-finger transition (implying broken movements of a jerky and clumsy character), as the latter fault may point to a lack of cerebellar co-ordination of agonists and antagonists during the single finger movement.

**Smoothness of movement: 0 = smooth placing of fingers on the thumb.**

1 = the child hesitates, sometimes misplaces a finger, gets the sequence wrong or wiggles a finger before placing it.

2 = many hesitations and misplacements with associated movements of other fingers which hamper adequate placing.
Finger-to-finger transition:

0 = easy and immediate transition.
1 = the child puts the same finger on the thumb several times at the turn.
2 = the child repeatedly puts a finger on thumb before going on the next finger.
3 = the child repeatedly puts a finger on the thumb and does not go on to the next finger even when he wants to.

Mirror movements:

0 = no associated movements in the opposite hand.
1 = barely discernible associated movements.
2 = marked associated movements.

Significance

Most children aged six and over can perform this test. A score of 0 or 1 for finger-to-finger transition and smoothness of movement is possible in normal eight-year-olds. A score of 1 for mirror movements may be present up to the age of 10 years. Girls usually perform this test better than boys.

This test, and particularly the score for 'smoothness of movement', reflects a complex motor performance which requires a neat differentiation in the use of the intrinsic muscles of the hand and fingers. The cerebral cortex is probably involved to a larger extent in this test than in the earlier less complex tests. This is suggested by the fact that the finger-opposition test may be carried out imperfectly even when the finger-nose test and finger-tip-touching tests are performed adequately. Presumably, the finger-opposition test reflects an aspect of the maturation of the cerebral cortex in instances when the cerebellar and proprioceptive systems are already developed. Naturally, hand preference is an important quality in the factor of the performance. Learning is also important, and it is advisable to let the child practice five sequences before his performance is scored. Young children often have difficulty with this test, so the examiner must make quite sure that the child knows what he has to do before the test begins.

What was said previously about elbow support against the body applies here too, especially with regard to hypotonia.

Some children show mirror movements in the resting hand, and these mirror movements may indicate a retarded maturation of the nervous system. Most children of 10 years and over show no mirror movements, and girls usually show fewer associated movements.

CIRCLE TEST

Age

This test is suitable for most children of six years of age and over. Some agile five-year-olds are also able to perform it.
Procedure

The examiner describes circles in the air with his extended index finger, wrist and forearm (elbows semi-flexed). He makes the movements with both arms simultaneously but in opposite directions. The child is asked to copy the movements. After completing four or five circles, the movement is repeated in the reverse direction. Then, without a pause, the circular movements are made with both arms in the same direction. After completion of about five circles in this way, the direction is reversed.

Recording

Attention is paid to the ability to copy mirror circles in both directions (to the left and to the right), to the ability to copy uni-directional circles in both directions, and to the transition between the motor patterns of mirroring and uni-directional circling of hands and forearms.

- **Mirror circles:**
  - 0 = perfect circles with both hands and arms.
  - 1 = different quality of the circles between both hands and arms.
  - 2 = badly shaped circles or even unrecognizable pattern on both sides (e.g. horizontal or vertical swipes or swaying movements).

- **Unidirectional circles:**
  - 0 = perfect circles with both hands and arms.
  - 1 = different quality of performance between both sides.
  - 2 = badly shaped circles or even unrecognizable pattern on both sides.

- **Transition between mirror and unidirectional circles:**
  - 0 = immediate and smooth transition.
  - 1 = hesitation and/or two or three badly-shaped unidirectional circles during transition.
  - 2 = distorted unidirectional pattern.

Significance

Assuming that co-ordination is intact and well-developed, this test evaluates the cooperation and interplay between the right and left side of the brain. In six-year-old children, and in many five-year-olds, the first part of the test can be carried out easily, mirroring being an easy problem for the brain; but the second part (in which both sides have to be in close interaction as far as time and rhythm are concerned, but in an opposite action regarding the direction of the movement) gives rise to many difficulties. Seven-year-olds can perform both parts, but often have difficulties with the transition, so that they often need a pause between the two parts in order to be able to perform correctly. From the age of eight years onwards, a score of 0 can be expected for both parts of the test and for the transition. Bad scores in this test usually accompany bad scores in the former two tests, and may be interpreted as a developmental retardation of cortical functions - when no other deviant signs indicating sensorimotor dysfunction are present.

Laterality can influence the performance, and six- and seven-year-olds may make better circles with the preferred hand. Elbow support against the body may occur, especially in young and/or hypotonic children.
In children of 10 years of age and over, the test can be done by drawing circles with fingers and wrists only, keeping the elbows still during the performance. 10-year-olds usually still need some co-movement from the elbows, but from 12 years of age onwards an adequate performance may be expected without such co-movements.

**Walking on Tiptoe**

The child is asked to walk on tiptoe for approximately twenty paces and back.

**Recording**

0 = unable to walk on tiptoe
1 = heel raised for a few moments only
2 = the heel remains off the ground
3 = the child walks well on tiptoe

Any head, body or arm movements which are not present in ordinary walking must be recorded as associated movements. (Slight swinging of the arms, for instance, is acceptable.) Associated movements are seen most clearly in the arms and face. Generally, the arms and hands extend and lip and tongue movements may also be present. Clenched fists may be seen, but are considered as associated movements only when they are accompanied by extended arms.

0 = no associated movements visible.
1 = barely discernible movements in the arms and hands only.
2 = marked extension of the arms and hands, or extension of the arms with clenched fists.
3 = same as '2' above, plus abduction of the upper arms and/or lip and tongue movements.

**Significance**

Children over three years of age should be able to walk on tiptoe; some younger children are also able to do so, but if they cannot no abnormality is indicated. A poor performance may be due to hypotonia or flexor hypertonia, and a very good performance may be due to extensor hypertonia. Asymmetries may indicate a lateralisation syndrome and should be carefully investigated after having first established that there are no deformities of the feet or other possible non-neurological causes. Mild hemisyndromes may present with walking on tiptoe and on heels before they can be seen in ordinary walking or can be felt while testing the resistance against passive and active movements. Corroboration of the unilateral findings can then usually be obtained by inspecting the sitting posture, standing posture and the posture of legs and feet while the child is lying in prone and supine positions. Bilateral foot deformities may also influence performance.

Associated movements usually decrease with increasing age, and should have disappeared by the age of seven or eight years. The persistence of associated movements is one possible manifestation of slow neurological development.

**Walking on heels**

**Procedure**

The child is asked to walk on his heels over a distance of approximately twenty paces and back.
Recording

0 = unable to walk on heels.
1 = toes raised for only a few moments.
2 = toes remain off the ground.
3 = the child walks will on the dorsal half of the heels.

Any movements of the head, body or arms which are not present in ordinary walking must be recorded as associated movements. Associated movements are seen most clearly in the arms and face: the arms flex at the elbow; the wrists hyperextend and the fingers flex at the interphalangeal joints; the fingers may also be extended. The upper arms are often abducted at the shoulder joint, and lip and/or tongue movements may be observed.

0 = no associated movements visible.
1 = barely discernible flexion of the elbows and hyperextension of wrists.
2 = marked flexion of the elbows (<60°) and hyperextension of the wrists.
3 = as for '2' above (but elbow flexion >60° with abduction of the shoulders and/or movements of lips and tongue).

Significance

Children over the age of three years should be able to walk on their heels, and some younger children may also be able to do so. A poor performance may be due to hypotonia of the lower leg muscles or paresis. It is of particular interest to note here that paresis of the peroneal muscles may occur without other muscles being impaired to the same degree. The child will walk on the outer side of the foot rather than on the heels, or, in mild cases, will commence walking on the heel but will fail and soon afterwards will walk on endorotated feet. Mildly hypotonic children who walk on the instep during the test for ordinary walking may show the same phenomenon, with no signs of muscle paresis. Non-hypotonic children who walk on the instep (mainly children under six years of age) usually walk normally on the heels. As already tested in the section on walking on tiptoe, the presence of a mild hemisyndrome may be discovered by close inspection of the symmetry of walking on the heels. Clearly, any foot deformities will interfere with performance. Asymmetries may indicate a lateralisation syndrome or they may result from non-neurological causes (e.g. unilateral foot deformities, arthrogenic origins).

Associated movements disappear at an earlier age for the test of walking on tiptoe than for walking on heels, but these movements have usually disappeared from the performance of walking on the heels by the age of nine or ten years. The persistence of associated movements at this age may be interpreted as a sign of slow neurological development.

Standing on one leg

Procedure

The child is asked to stand on one leg for at least twenty seconds. Each leg is tested in turn, the child being allowed to start with whichever leg he prefers.
**Recording**

The performance of each is recorded separately and a note is made of which leg the uses first.

0 = unable to stand on one leg.
1 = tries, but has to put foot down again.
2 = 3-6 secs.
3 = 7-12 secs.
4 = 13-16 secs.
5 = 17-20 secs.
6 = more than 20 secs. This is regarded as a mature performance.

Swaying or 'balancing' movements are also recorded, and it is noted whether they are abrupt and jerky or continuous.

**Significance**

The ability to stand on one leg develops quite suddenly and improves rapidly. At three years of age only a few children can stand on one leg for longer than five to six seconds; at five years, most children can carry on for 10 to 12 seconds; at six, 13 to 16 seconds is normal; and by the age of seven or eight, most children are able to stand on one leg for more than 20 seconds.

The difference between the performance of the preferred and the non-preferred leg is greatest at the age of four and five years and decreases with age. At the age of three or four, a difference of 1 or 2 points is not unusual. At this age, many 'balancing' decreases and the ability to stand on one leg is similar for each side. The persistence of continuous balancing movements after the age of seven years can be regarded as a sign of slow development of equilibrium.

Sudden jerks which nearly throw the child off balance may be due to involuntary dyskinesia such as proximal choreiform movements.

It should be noted that the preferred leg for standing and hopping is not always the same as the one for kicking a ball for instance. Children under seven or eight years often choose their preferred leg for standing (i.e. for stabilisation) and use their non-preferred leg for kicking the ball. The reason is that their balance at this age is still quite poor, and they need the more differentiated leg for this balancing. Children over the age of eight years usually kick the ball with their preferred leg, for at this age they can maintain balance with their non-preferred leg, leaving the preferred leg for more complex tasks such as estimating force and directing the ball.

Asymmetrical performances should be interpreted very carefully. Extreme cases of asymmetry may reflect a lateralisation syndrome, in which case there will undoubtedly be other signs of nervous dysfunction which show an analogous pattern.

Involuntary movements, particularly choreiform movements or tremor, will interfere with the child's performance. A low score for each leg, unaccompanied by dyskinesia, may result from a retardation in functional maturation, generalised hypotonia or from cerebellar or sensory dysfunction.

**Hopping**

**Procedure**

The child is asked to hop on each foot at least 20 times, starting with whichever leg he prefers. Hopping on the spot is best, but children younger than six often cannot manage this and so should be allowed to move forward. The child is asked to hop on his toes, and not with the whole foot.
**Recording**

The performance of each foot is recorded separately, and the preferred leg is recorded.

0 = unable to hop.
1 = 2-4 hops.
2 = 5-8 hops.
3 = 9-12 hops.
4 = 13-16 hops.
5 = 17-20 hops.
6 = more than 20 hops.

The amount of swaying and balancing movements are noted, as well as the child's ability to remain hopping on his toes. Hopping on the whole foot can be heard as well as seen. Evident asymmetries in arm posture should be recorded.

**Significance**

The development of this motor function is abrupt and rapid. At three years, very few children are able to hop even a few times, and then it is usually only on one foot; whilst at four years five to eight hops is a normal score. At five years, nine or 10 hops are possible; and at six years between 13 and 16 hops. At six years about 25 percent of children can hop more than 20 times on one foot at least. At seven or eight years, the majority of children can hop more than 20 times with each foot.

The presence of continuous balancing movements after the age of seven years may reflect a slow development of equilibrium. Abrupt and jerky disturbances of balance may be due to choreiform or some other involuntary dyskinesia.

Children below the age of seven may or may not hop on the whole foot: they may start on tiptoes and then gradually begin to use the whole foot. Hopping on the whole foot in older children usually reflects hypotonia.

Asymmetries in arm posture during hopping may be a sign of mild lateralisation. Between the ages of five and seven, one leg is often better than the other one, though, as with standing on one leg, the best leg is not necessarily the preferred leg in playing football, for example. The relationship of hopping to the concept of dominance is a complex one; consequently, an asymmetrical performance must be very carefully interpreted. The greater the discrepancy between left and right, the greater the possibility of a hemisindrome or other lateralisation syndrome as the underlying cause. If such a lateralisation is present, other neurological findings should corroborate it.

A weak performance on both sides may reflect a retardation in maturation; neurogenic, myogenic, static or arthrogenic causes must also be considered. Pain from a different origin may also interfere with performance.

It is possible that training may influence results, but as most children at play hop only on their leg of preference, the training will be asymmetrical. As in the cases of other tests such as diadochokinesis and standing on one leg, girls tend to perform better than boys.
## Alphabet Syllable Diagnostic Lists For Speech Hearing

<table>
<thead>
<tr>
<th>List #1</th>
<th>List #2</th>
<th>List #3</th>
<th>List #4</th>
<th>List #5</th>
<th>List #6</th>
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</thead>
<tbody>
<tr>
<td>1. ATZ</td>
<td>1. AKE</td>
<td>1. TZA</td>
<td>1. EAK</td>
<td>1. BLN</td>
<td>1. ABT</td>
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<td>2. CSB</td>
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<td>2. GPT</td>
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<td>22. BZC</td>
<td>22. DPZ</td>
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<td>23. CDE</td>
<td>23. TNN</td>
<td>23. TEA</td>
<td>23. NZA</td>
</tr>
</tbody>
</table>

### Procedure for administering the test:

1. The test should be carried out in a quiet room.
2. The testee is seated six feet away and with his/her back to the clinician in order to avoid visual clues.
3. Twenty-five lines of three letters each are presented to the testee (total number of letters=75)
4. Scoring consists of dividing the number of correct answers by the total possible to obtain a percentage. A person with no hearing loss should get from 95% to 100% correct answers.

BIBLIOGRAPHY


